

# OATS. BARLEY. RYE. RICE. GRAIN SORGHUMS. SEED FLAX & BUCKWHEAT



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## Introduction.

OF the seven crops named, the first five are members of the grass family, while the last two represent two different and unrelated families. Only members of the grass family properly are called cereals. Flax really is an oil crop and is grouped with the cereals because it is a field crop grown in the same areas and handled largely by the same machinery and processes. Buckwheat, while not a true cereal, is used as a flour grain, and hence is a cereal substitute.

The true cereals grown extensively in the United States are wheat, oats, barley, rye, and rice, commonly called "small grains," and corn (maize) and the grain sorghums, which might be called "large grains," by way of contrast. Commercially oats, barley, and corn, used chiefly for feeding animals, are called "coarse grains," in distinction from wheat, rye, and rice, used chiefly for feeding humans, and often called "food grains." The comparative values of most

## COMPARATIVE VALUE OF 11 FARM CROPS IN THE UNITED STATES.

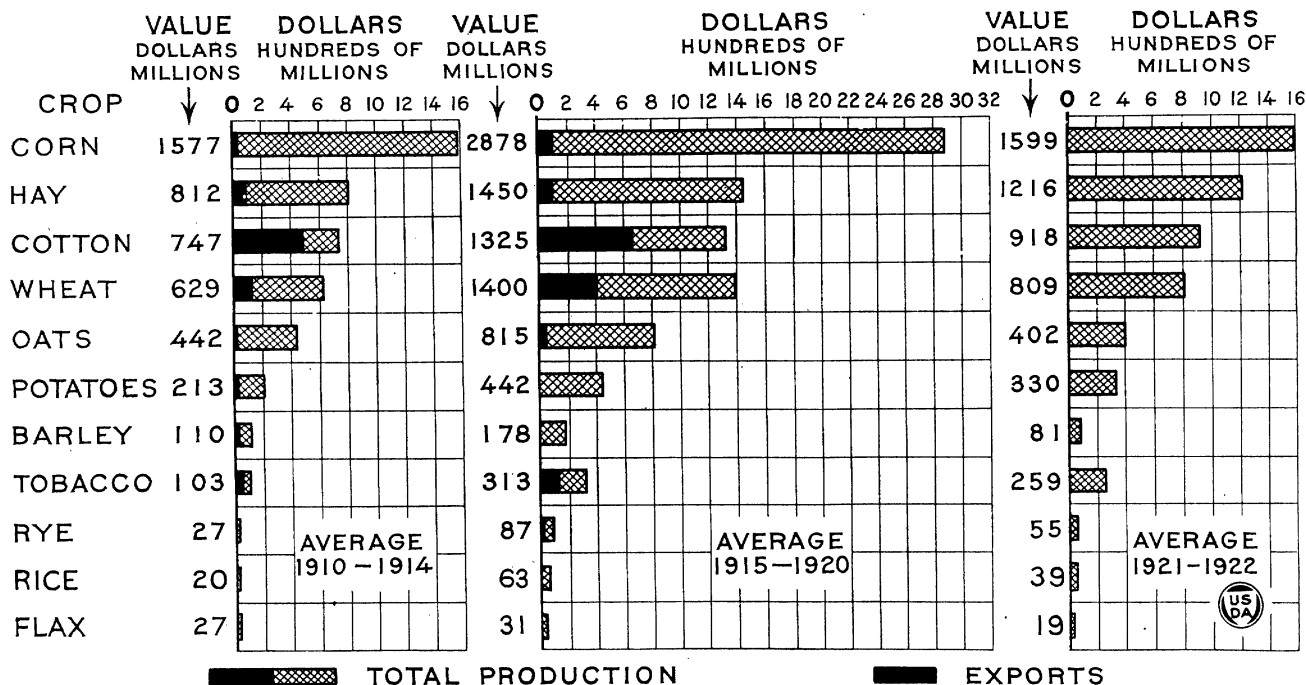


FIG. 1.—Oats ranks fifth in value among the crops in all three periods. Barley ranks seventh or eighth, rye ninth, rice usually tenth, and seed flax eleventh.

of these cereals and of some other farm crops, in different periods, are shown in Figure 1.

In the following treatment of these crops some phases of their production are discussed for each crop separately, while other phases are discussed for all or part of them combined. Each crop is discussed separately, for instance, with reference to its importance, world production, the trend and historical development of production in the United States, factors affecting production (including soil, climate, diseases, and insects, as well as some special economic factors), and the problems of marketing, quality, domestic uses, and exports. Costs of production and crop position are discussed in special chapters after the individual crops.

Wheat and corn were treated in full in the Yearbook of 1921 and are not discussed here, except in so far as they affect these other crops in farm organization and in uses.

Damage by rodents to agricultural products, chiefly grain crops, in the field has been estimated by the Department of Agriculture at more than \$150,000,000 annually, while house rats and mice take an added toll of \$200,000,000 through damage to grain and its products in storage and transit.

### Food Value of Cereals.

Cereal grains are very valuable foods because of the large amount of starch, about 75 per cent of the total grain, which they supply for body fuel, and the 8 or 10 per cent of protein which, with 2 per cent of ash and 2 to 3 per cent of fat, make up the nutritive substances present. The germ portion of the grain supplies vitamine and the outer or bran layers add bulk to the diet and are regarded as laxative. The average fuel value is around 1,600 calories per pound.

### Oats.

#### The Importance of Oats.

Of the major cereal crops of the United States the oat crop ranks third in importance. In acreage and value it is exceeded only by corn and wheat (Fig. 1). The important and rather unique place this crop occupies, regardless of the fact that its cash value alone seldom offers much inducement

for production, is due to (1) its unsurpassed feeding value for horses and young stock, (2) the difficulty of replacing it by any other crop in our general farming system, and (3) the economy of labor in growing and handling the crop.

Oats traditionally constitute the banner horse feed of the world. Their bone and muscle building ingredients also make this grain most valuable for feeding young stock, as well as for feeding breeding stock.

Oats usually are not considered a cash crop. They are grown largely to complete the rotation system in order that wheat and other cash crops may be grown successfully. There is no other crop that fits in as well as do oats between corn and wheat or corn and grass in the rotations and utilizes land and some labor that might otherwise be unproductive. In some sections barley or soy beans may be substituted with good results, but under most conditions these crops have certain disadvantages that still make oats the most satisfactory intermediate crop.

Economy of labor in the production of oats also is an important factor. Usually no plowing is necessary in preparing the seed bed, particularly where the crop follows corn.

#### World Production of Oats.

The distribution of oat acreage throughout the world and the average percentage of total production which was furnished by each of the leading producing countries in about five years ending with 1914 is shown on the map in Figure 2. The two great centers of oat production were found in western Europe and the north-central portion of the United States. Slightly more than one-fourth of the world oat crop was produced in the United States. Russia was a very close second, with 24 per cent of the total. Other countries of large production were Germany, Canada, France, Austria-Hungary, and the United Kingdom, in the order named.

During the 20-year pre-war period from 1895 to 1914, inclusive, the annual production of oats in the United States averaged, in round numbers, 969 million bushels, in Russia 901, in Germany 523, in France 317, in Austria-Hungary 221, and in the United Kingdom 176 million bushels. In

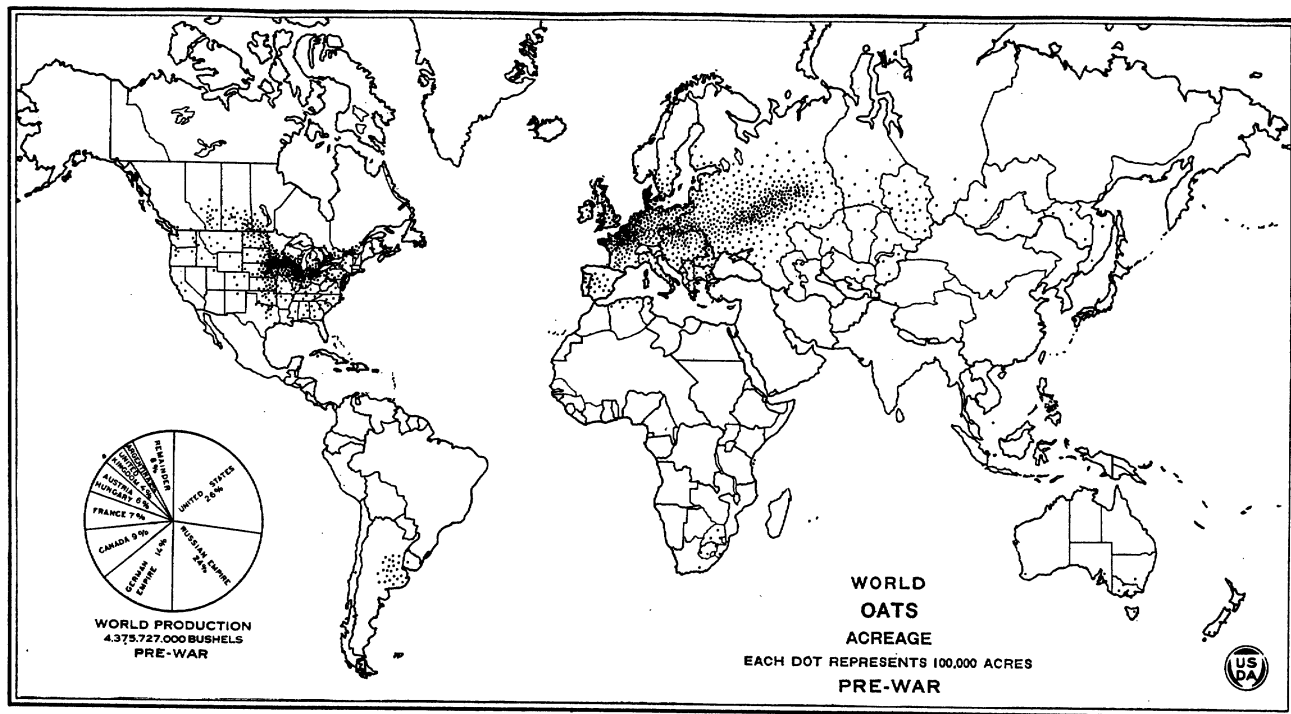


FIG. 2.—Pre-war oat acreage and production of the world. The United States led in acreage then, with Russia a close second. Germany, Canada, France, and Austria-Hungary followed in the order named. Complete postwar statistics are not available from several important producing countries. Like wheat, most of the world oats is produced in the North Temperate Zone.

the last seven years of this period Canada, for which earlier annual statistics are not available, outranked both the United Kingdom and Austria-Hungary. In the period from 1915 to 1922, inclusive, average production in the United States has increased about one-fourth over that of the pre-war period.

The production of the oat crop is chiefly in the cooler portions of the North Temperate Zone. A relatively small production occurs in Australia, South Africa, and South America. In Europe, especially, oats are grown in a cooler and moister climate than wheat. The northern geographical limit of oat production extends to the Arctic Circle in Sweden and Finland.

Oats, like rye, enter much less into commerce than wheat or barley, because they are too bulky in relation to price to bear the cost of long-distance transportation. Therefore, the greater portion of the crop always is consumed in the country in which it is produced.

#### Trend of Production in the United States.

Acreage and production of oats in the United States have increased rapidly and consistently since annual estimates became available in 1866 (Fig. 3). However, production has shown some fluctuation, due chiefly to low acre yields in poor oat years and high acre yields in good years. The peak of production occurred in 1917, when the United States produced 1,592,740,000 bushels of oats. The largest acreage up to the end of the World War was grown in 1918, when 44,349,000 acres were harvested, from which 1,538,124,000 bushels were garnered. The heavy drop in acreage in 1919 was followed immediately by a rise to 42,491,000 acres in 1920, and a still further increase to 45,495,000 acres in 1921, the greatest acreage ever grown. Following the record acreage of 1921 with an average acre yield of 23.7 bushels, the lowest since 1890, a decided drop in acreage occurred again in 1922, when only 40,693,000 acres were grown. The acre yield also has increased rather steadily since about 1890.

The farm price of oats fell while the acreage was expanding rapidly, and continued to fall to 1896, since which year the trend of prices has been upward.

**OATS: ACREAGE, PRODUCTION, ACRE YIELD, AND FARM PRICE, UNITED STATES, 1866-1922.**

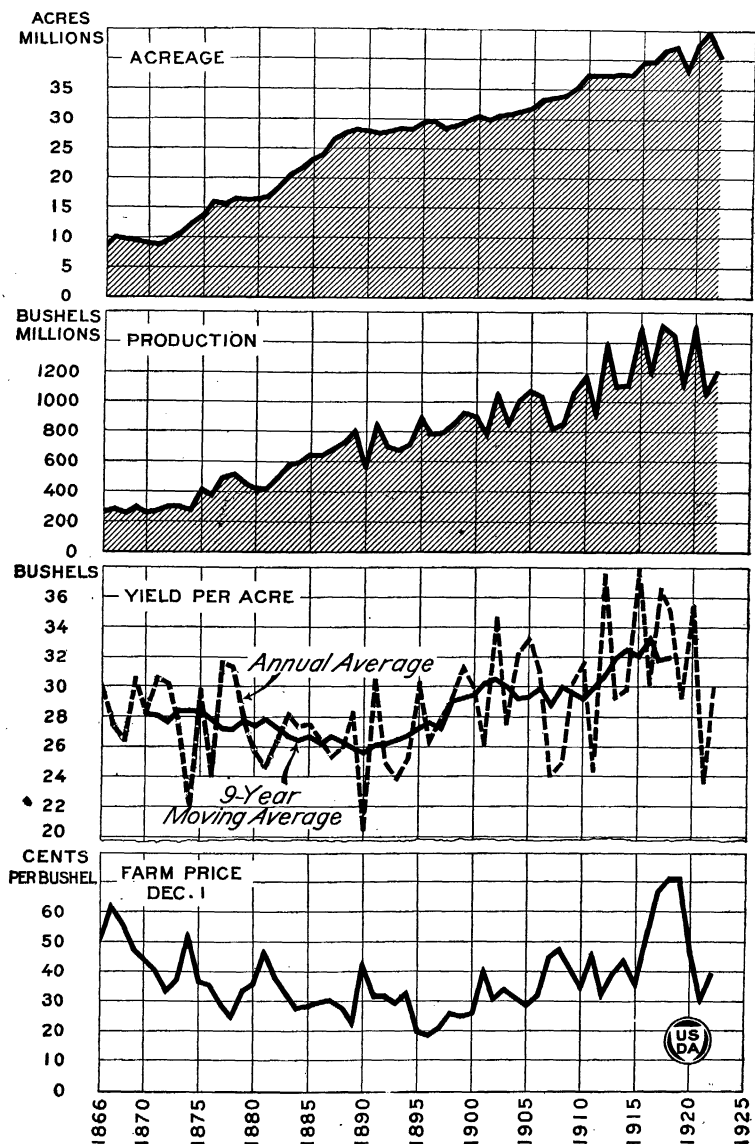


FIG. 3.—The average of oats has increased steadily since 1865, though the production shows the effects of seasonal variations in yield. Acre yield increased in general from 1890 to 1915, but apparently has decreased since. Price was lower in 1921 than at any time since 1905.

### Historical Development of Production.

The early history and development of oat production in the United States closely parallels that of wheat. Culture of the crop began on the Atlantic seaboard about 1630 or earlier, and was carried westward with the march of settlement. Like wheat, the first great shift in oat production westward followed the close of the Revolutionary War and extended up to the middle of the last century. Production in this period was carried across the Appalachian Mountains into the Ohio Valley and the prairie region immediately to the west (Figs. 4-11).

From 1871 to about 1890 was a period of very rapid expansion in oat acreage, as it also was a period of very rapid expansion in American agriculture. As the area expanded the acre yield dropped. This expansion took place mostly in the Corn Belt. From 1890 to about 1905 the area seeded to oats expanded more slowly and the acre yield increased, resulting in a gradual increase in production. This was followed by rapid expansion of acreage in the upper Mississippi Valley, which raised the acreage to the high point reached in 1918.

### Natural Factors Influencing Production.

Among the important natural factors influencing the production of oats from year to year are climatic conditions, such as moisture and temperature, and pests, such as fungous diseases, insects, and rodents. Those making up the climatic conditions are the most important.

Oats attain their best growth in regions of cool, moist climate, such as are found in many of the northern European countries, in the northern United States, and in Canada. In these areas the varieties of the species *Avena sativa* L. are grown exclusively, and are spring sown. In the United States this type of oat is best represented by such well-known varieties as Swedish Select, Silvermine, Kherson, White Tartar (White Russian), etc.

In regions of high temperatures, such as the Mediterranean countries, Australia, the southern United States, and California, this type of oat is not adapted. In these areas



the culture of oats is limited to the varieties of another species, *Avena byzantina* C. Koch (*A. sterilis* L.). This is a distinct type, adapted to warm climates, and is represented in this country by the well-known Red Rustproof variety and its relatives. In the southeastern States, where the winters are mild, the Red Rustproof oat is grown from both fall and spring sowing.

*Moisture.*—The great oat-producing areas are confined mostly to the more humid portions of the United States. Precipitation therefore is not as much of a limiting factor in the production of oats as in wheat. The seasonal distribution of the precipitation in the production of oats frequently is more of a limiting factor than the total rainfall.

*Temperature.*—Conditions of temperature also frequently have a similar effect. The occurrence of hot, dry weather during the ripening period is one of the most common causes of reduced production in the Corn Belt. As less than one-tenth of the oat crop is fall-sown, winter-killing is not an important factor in oat production.

TABLE 1.—*Estimated annual loss of oats from disease, 1917–1921, inclusive.*

Disease.	1917	1918	1919	1920	1921
	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>
Smuts.....	91,648,000	64,396,000	39,238,000	40,143,000	35,810,000
Stem rust.....	27,502,000	( <sup>1</sup> )	15,027,000	14,783,000	16,223,000
Crown rust.....		( <sup>1</sup> )	15,167,000	6,785,000	21,874,000
Other diseases.....	34,825,000	( <sup>1</sup> )	8,915,000	16,488,000	25,252,000
Total loss.....	153,975,000	( <sup>1</sup> )	78,347,000	78,199,000	99,159,000

<sup>1</sup> No estimate made.

*Fungous diseases.*—The oat crop is subject to several diseases, chief among which are loose and covered smuts, stem rust, and crown rust. Of these, the smuts and stem rust are the most destructive. The smuts are easily controlled by seed treatment, a practice now quite generally adopted throughout the principal oat-producing sections of the country. The rusts, however, can be controlled only through the general adoption of rust-resistant varieties, the develop-

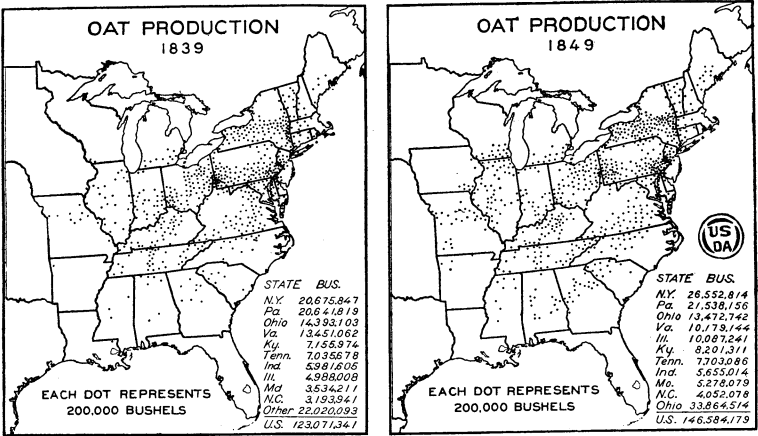


FIG. 4.—In 1839 production of oats was confined almost entirely to the territory east of the Mississippi River. Already more than half the oats produced were grown west of the Allegheny Mountains, the Ohio Valley having become an important area of production. Production was just beginning in southern Michigan and in Illinois. In the decade ending with 1849 the States leading in production remained the same as in 1839. Production advanced slightly northward in Michigan and Wisconsin. The growing of oats spread rather generally over Missouri and production began in southeastern Iowa. There also was some expansion southward.

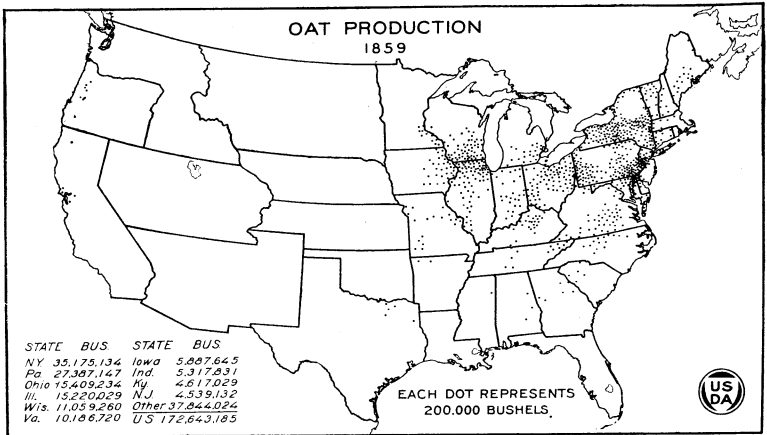


FIG. 5.—During the decade ending with 1859 oat production continued its advance westward. With the settlement of California, following the discovery of gold, production began in that State. Production also was started in western Oregon. Rapid expansion took place northward into Michigan and Wisconsin and westward into Iowa. Oat growing was started in southeastern Minnesota and also in northeastern Texas. Coincident with a marked decline in the South, Illinois, Iowa, and Wisconsin were rapidly becoming important States in oat production.

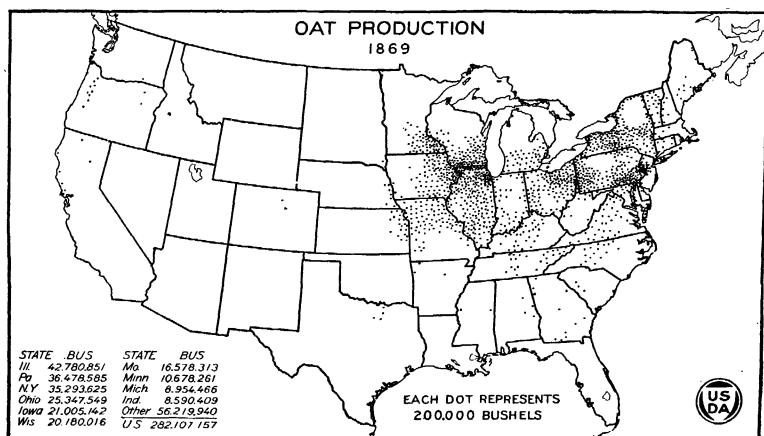


FIG. 6.—In the 10-year period ending with 1869 there was a notable shift westward in the production of oats. The center of production moved from the Ohio Valley to the Upper Mississippi Valley. Illinois replaced New York as the leading State in production. Oat production crossed the Missouri River into Nebraska and Kansas, and also increased in the Pacific Coast States. The greatest expansion occurred in Illinois, Iowa, Wisconsin, and Minnesota. In the States east of these there were no marked changes.

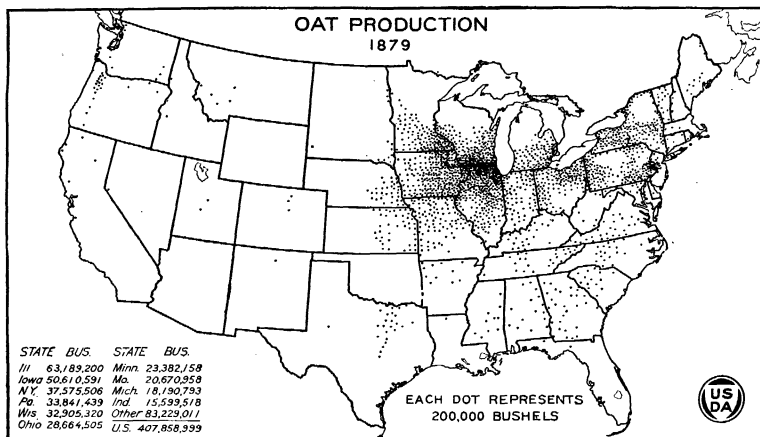


FIG. 7.—During the 10-year period ending with 1879 the westward advance of oat culture continued. Iowa became important and pushed New York into third place. Production also extended northward in Wisconsin and Minnesota, and these had become important oat-producing States. There was a slight resumption of oat production in Georgia and Alabama and some expansion in northeastern Texas. The California production declined, but that in the Rocky Mountain and Great Basin States increased rapidly.

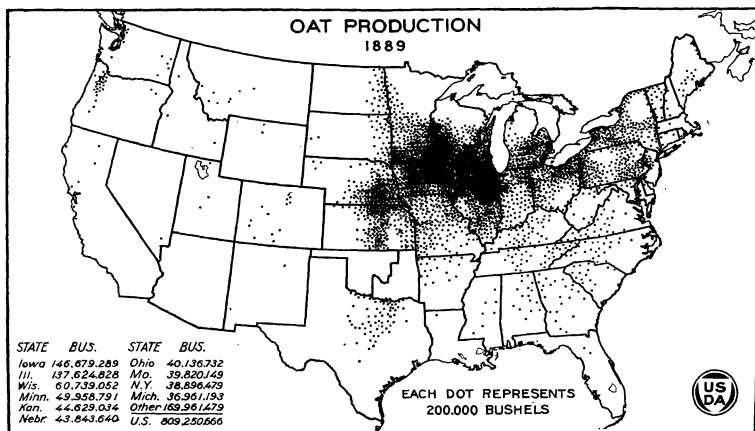


FIG. 8.—During the decade ending with 1889 the total oat production in the United States was doubled. While there was a marked extension westward into Kansas, Nebraska, and the Dakotas, the great increase in production was due mostly to the enormous expansion of oat acreage in Illinois and Iowa, following a decrease in spring-wheat production. These States had become decidedly the most important in oat production. The development of the self-binder as an efficient implement of production contributed largely to the great increase of oat production during the decade, particularly on the rich prairies of the Upper Mississippi Valley States.

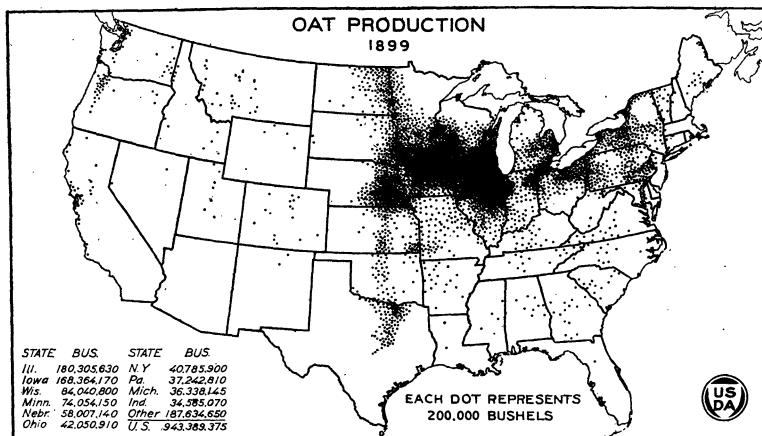


FIG. 9.—In the decade ending with 1899 no great increase in the total production of oats occurred. This apparently was due to an overproduction and the extremely low farm prices which prevailed at that time. With the concentration of oat production in the States of the Upper Mississippi Valley, particularly in Illinois and Iowa, and a corresponding development of railroad transportation, a slight decline in oat production took place in New England, eastern New York, New Jersey, and the South Atlantic States.

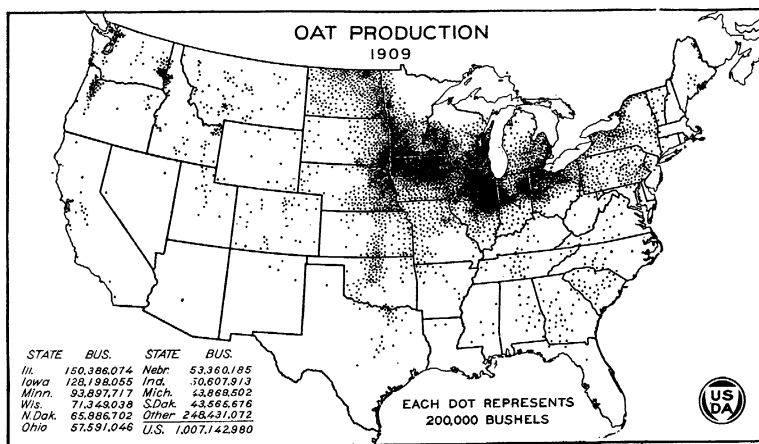


FIG. 10.—Total oat production in the United States in 1909, as in some previous years in this decade, exceeded a billion bushels. The expansion of oat growing in Minnesota, the Dakotas, and other more western States contributed largely to the increase in total production. The decreased production in Illinois and Iowa as compared with 1899 was due more to a lower acre yield in 1909 than to decreased acreage.

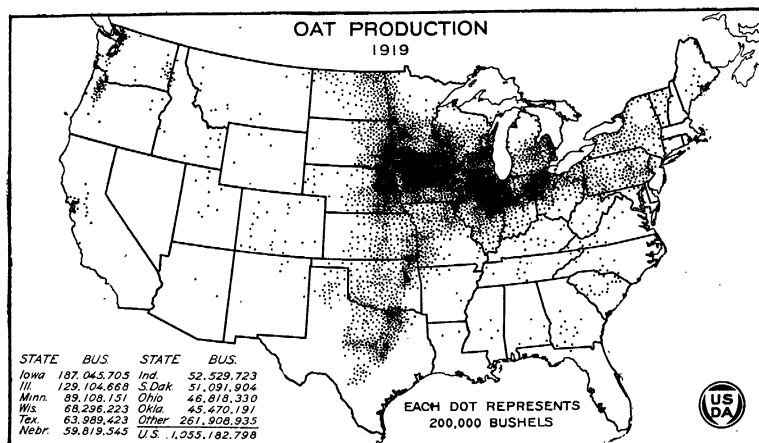


FIG. 11.—During the decade from 1910 to 1919, inclusive, a second great increase in oat production took place in the United States (see Fig. 3), though both acreage and production were low in 1919. In this period the annual production of oats reached the enormous figure of  $1\frac{1}{2}$  billion bushels, or a third of the world's production. This second great expansion of oat production was due primarily to the advent of the World War which stimulated prices. More oats were grown in the oat belt and in the southern half of the Great Plains area, especially in central Texas, in 1919, but fewer in the West and Southeast.

ment of which appears promising. The relative economic importance of the diseases of oats is given in Table 1.

*Insects.*—The growing oat crop is almost free from insect attack except for the periodical inroads caused by outbreaks of the green bug and the oat aphid. This crop is the preferred food of the green bug; but were it not for the lax methods of culture in vogue in parts of Texas, Oklahoma, Kansas, and Missouri in permitting the continuous growth of volunteer oats for forage purposes, this source of interference with the production of oats would be practically eliminated. In 1907 and in 1910 outbreaks of the green bug in the section mentioned caused the abandonment of at least 50 per cent of the acreage in the districts most severely affected.

#### Marketing Oats.

The oat crop is not as important commercially as wheat and corn. According to the census data, slightly less than a third of the national production of oats in 1919 was sold by farmers. Farm consumption apparently absorbed the remainder of the crop. Of the part sold by farmers a larger proportion goes to terminal markets than in the case of corn, much of which is sold by one farmer to another for feeding and thus never reaches the terminals.

The United States grain standards act requires oats offered for sale in interstate shipment to be inspected and graded by a licensed inspector in accordance with the official standards for oats. These standards divide oats into classes and grades which designate the kind, quality, and condition of the oats.

*Classes.*—For commercial purposes oats are separated on a color basis into four classes, namely, white, red, gray, and black oats. In this classification white oats include yellow oats.

*Grades and grading.*—All classes of oats are divided into four numerical grades (1, 2, 3, and 4), dependent upon the following factors: Condition and general appearance, test weight per bushel, sound oats, heat damage, wild oats, and mixtures of other classes of oats. Oats failing to meet the specifications for any one of the four numerical grades are

graded "Sample grade." The oat inspectors are not employees of the Government, but are licensed by the United States Department of Agriculture for the purpose of making inspections. These inspectors usually are employed by State grain inspection departments, chambers of commerce, and boards of trade, but in some cases they operate independently on a fee basis.

*Quality as shown by grade.*—The annual variation in quality of each class, as shown by grade, for the three crop years July, 1919, to June, 1922, inclusive, and the three-year average are shown graphically in Figures 12 and 13.

### Oat Foods, Feeds, and Feeding.

About 3 per cent of the oat crop of the United States is milled for human consumption. This amounts, however, to many thousands of tons. The oat kernel resembles wheat in composition, but contains less carbohydrate and more fat. Oatmeal and similar oat preparations are commonly used as a breakfast food or porridge, and to a very limited extent for puddings and other dishes. A crisp oat bread often is made in England and sometimes in the United States. Oatmeal crackers also are manufactured here.

The by-products from the milling of oats are the basis of a large mixed-feed industry. These by-products are oat feed and oat middlings. They rarely are sold unmixed. The oat middlings are a valuable feed, being high in protein and low in fiber. The oat feed, however, contains oat hulls, often in large amount, which results in low protein and high fiber content, and therefore in lowered feeding value.

Oats are not directly comparable with corn (Fig. 14) as a fattening feed on account of their bulkiness and different composition. For breeding stock oats are superior to corn, as they are relatively richer in protein and mineral matter. Oats contain more crude fiber than any of the other common feed grains. Their greatest usefulness is in feeding horses, for which there is no better feed. Commonly speaking, for horse feeding 2 bushels of oats are equal to 1 bushel of corn. Because of the coarser nature there is not so much danger of overfeeding horses with oats as with corn. Oats are very

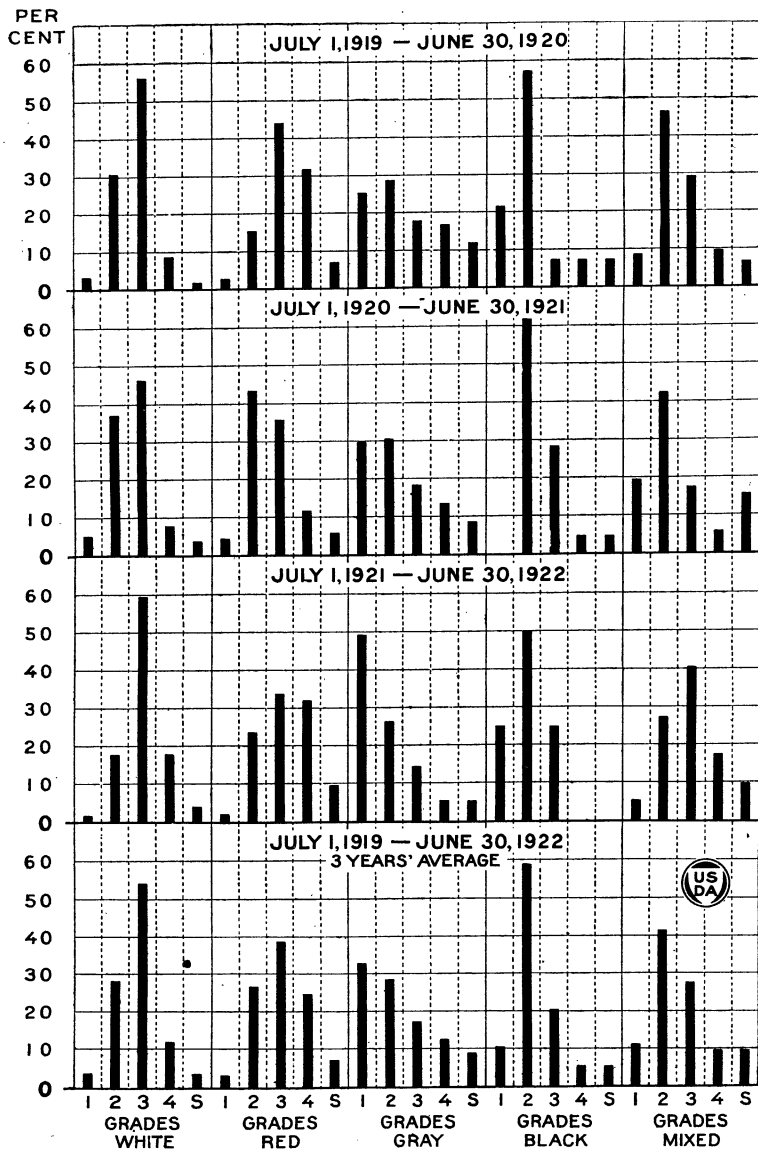
**OATS: ANNUAL AND AVERAGE VARIATION IN QUALITY.**

FIG. 12.—Annual and average quality of oats in the three crop-movement years from July 1, 1919, to June 30, 1922, as shown by percentage of total receipts falling into each grade in all five classes at all inspection points, and by the average for the entire three-year period. In most classes much the larger proportion of the total receipts falls into grades 2 and 3. In the gray-oat class, produced chiefly in Oregon and Washington, the larger proportion falls into grade 1. The tendency of oats to discolor quickly is responsible for the large quantity that falls into grade 2.



valuable for diluting a heavy grain ration, such as corn. They may be fed whole to mature stock, but for young stock they generally should be ground, or preferably rolled. For young stock, also, some less bulky grain should be included

#### AVERAGE QUALITY OF ALL CLASSES OF OATS.

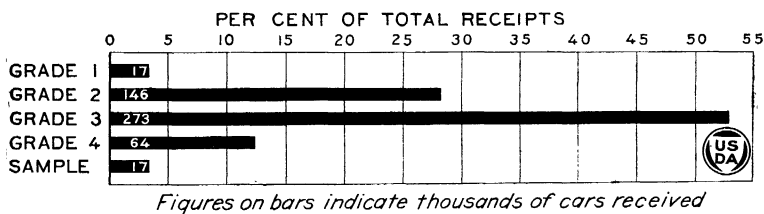


FIG. 13.—The average quality of all classes combined, being the average of the average by classes shown in the lower section of Figure 12, and covering the three years from July 1, 1919, to June 30, 1922. About 53 per cent of all classes fell into grade 3 and about 28 per cent into grade 2.

in the ration. Oats are shipped about the country in large quantities for use as horse feed, but seldom for other classes of live stock.

#### Situation and Outlook.

The production of oats in the United States probably has reached its highest point. It is probable that the acreage of this crop will be somewhat reduced during the present decade. The advent and rapidly increasing use of motorized

#### OATS AND CORN FOR FATTENING HOGS.

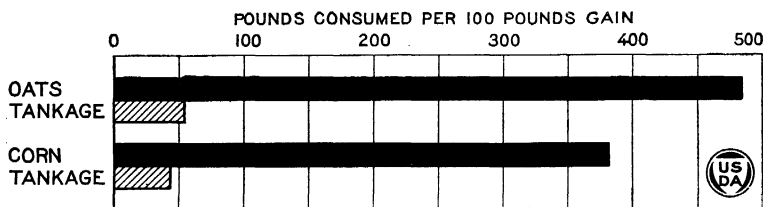


FIG. 14.—This graph is based on the results of two experiments at the Ohio Agricultural Experiment Station, as published in Bulletin 268. In the first experiment, two lots of 5 pigs each, averaging about 50 pounds, were fed for 126 days. The oat-fed pigs did not relish their ration at first. In the second experiment, two lots of 5 shotes each, averaging about 150 pounds, were fed for 84 days. It is concluded that whenever corn is worth more than  $2\frac{1}{2}$  times as much as oats per bushel, oats can be satisfactorily used to fatten hogs, especially in the first part of the feeding period.

transfer and trucking in both the city and country are markedly reducing the commercial demand for feeding oats. The farm tractor also probably will reduce the number of work horses on the farm, thus further reducing the quantity of oats required. However, there still will remain a demand for oats by certain industries that will continue to use horses. Notwithstanding the rapid development of the farm tractor, a large percentage of the farms of the United States will continue to be tilled by the use of the horse as the chief source of motive power, and consequently oats will continue to be in demand as one of their principal feeds.

## Barley.

### Importance of the Crop.

Barley ranks fourth in importance among the cereal crops of the United States, being exceeded in value by corn, wheat, and oats (Fig. 1). The importance of barley in American agriculture is increasing, even though the production is not. The average annual production of barley for the 10 years 1913 to 1922, inclusive, was about 193 millions of bushels. This is not a large quantity when compared with the production of corn or oats; nevertheless, it is significant. Much barley is grown outside the regions where corn and oats do well and furnishes a grain feed for live stock in these regions. Barley gives a high return per acre in feed and the amount fed on farms where grown is constantly increasing.

### World Production.

The average annual world production of barley in the 10 years from 1906 to 1915, inclusive, was 1,400,000,000 bushels. This may be considered as the normal world crop. In pre-war times Russia produced over 25 per cent of the world crop. Over half of the total barley export of the world normally came from Russia.

Barley is extensively cultivated in northern India, central Europe, Spain, North Africa, and Japan (Fig. 15). The percentage of the cropped land in barley is highest in Algeria and Japan. Barley is a dominating crop in Al-

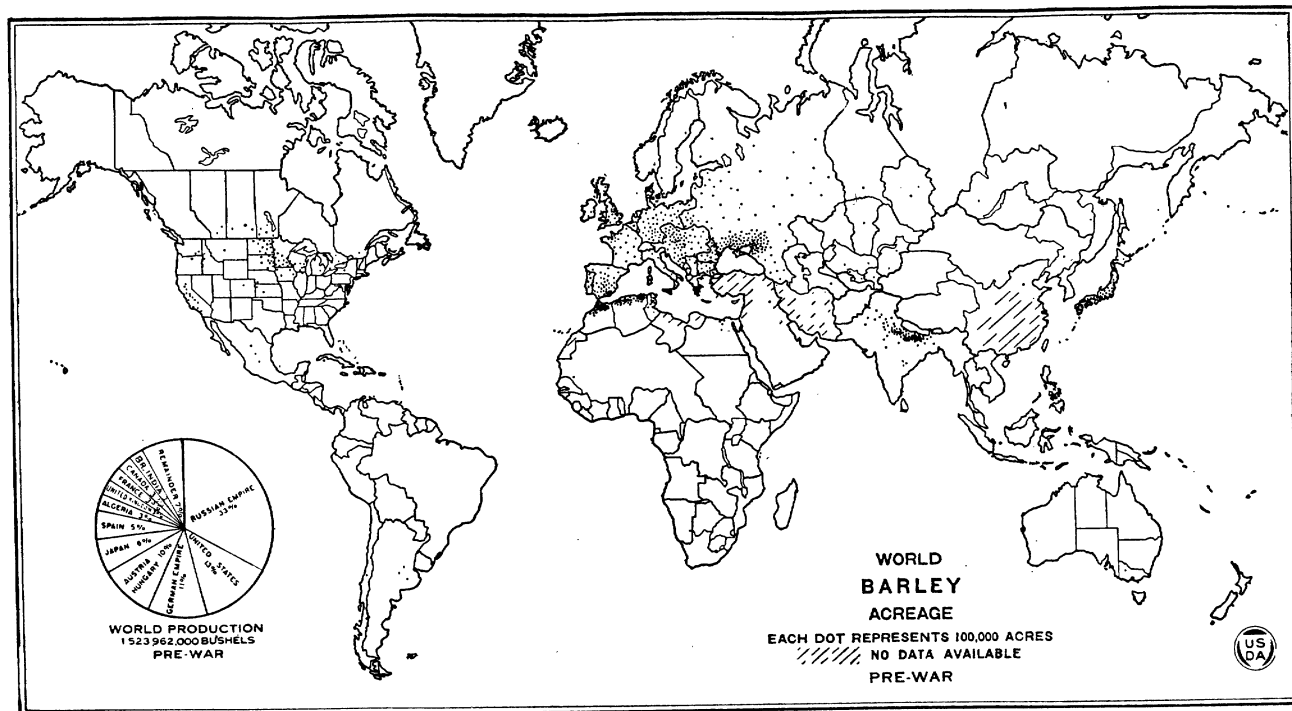


FIG. 15.—World pre-war acreage and world production of barley. No statistics were available for China, Persia, Asia Minor, and part of northern Africa. The four great centers of production are seen to be in southern and western Europe and northern Africa, the United States, British India, and Japan. Complete statistics are not available for many of the large producing countries, notably Russia, since the war.

geria. The climatic conditions of Algeria are not unlike those of California, where barley is the dominant crop in large sections. Since 1916 the average annual reported production has been little more than 1,000,000,000 bushels, but complete statistics have not been available from Russia and other important producing countries.

#### Trend of Production in the United States.

The acreage annually sown to barley increased uniformly from 1866 until 1910, when it reached more than  $7\frac{1}{2}$  million acres (Fig. 16). Since 1910 the average acreage of barley has been about stationary, although the annual acreage has fluctuated violently, due to war conditions.

The acre yield has remained close to 25 bushels since the Civil War. The areas of production have shifted greatly during the years since 1910, and especially since the enactment of prohibition legislation. While the acreage is the same total, the geographic location is quite different. In those sections where barley was grown as a money crop the acreage has decreased rapidly. This has been balanced by an increase on scattered farms over the whole barley-growing areas of the United States for the purpose of securing feed. The present trend is toward less localization of production and a greater farm use.

In Figure 17 are shown for the 14 years, 1909 to 1922, inclusive, the total production of barley, the quantity moved from the county in which it was grown, including exports, and the quantity consumed in the county where grown. The graph shows that there has been a steady decrease in the percentage of the crop shipped out and a correspondingly steady increase in the proportion used where grown. This has occurred in spite of the fact that exports have not decreased.

#### Historical Development of Production in the United States.

Barley was introduced by the early Dutch and English settlers into the Atlantic coast colonies and by the Spaniards into Mexico and the Pacific coast. In Mexico and California barley grew well, and the crop soon was established wherever there were settlements. In the East the districts first

**BARLEY: ACREAGE, PRODUCTION, ACRE YIELD, AND FARM PRICE, UNITED STATES, 1866-1922.**

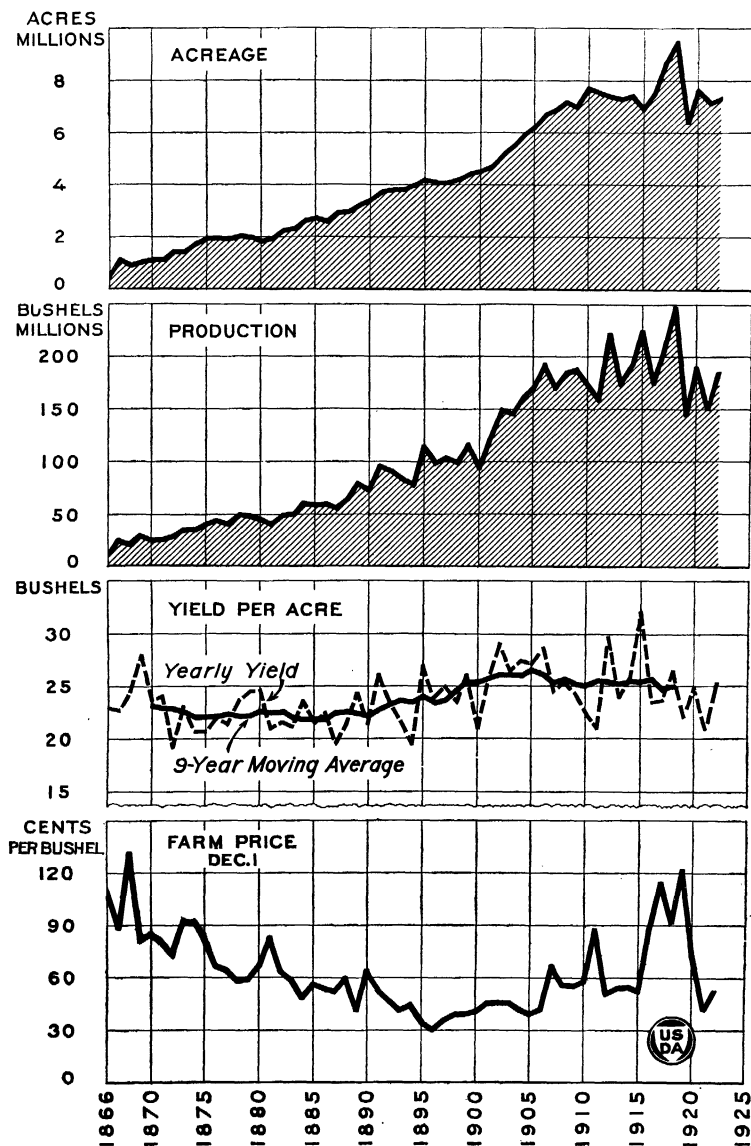


FIG. 16.—Acreage and production steadily increased since annual estimates became available in 1866 until very recent years. Acre yield also increased until 1905 and recently has been fairly stationary at about 25 bushels. Farm price decreased until 1896, then increased until 1919, and since then has dropped rapidly.

settled were not suitable for barley growing. Some barley was grown, but English malt was imported to supplement the domestic production.

It was only when central and western New York were settled that a large area favorable to barley production was brought under cultivation. Barley rapidly followed the progress of settlement into the interior States.

**BARLEY: PRODUCTION, EXPORTS, MOVEMENT FROM COUNTY WHERE GROWN, AND LOCAL CONSUMPTION, 1909-1921.**

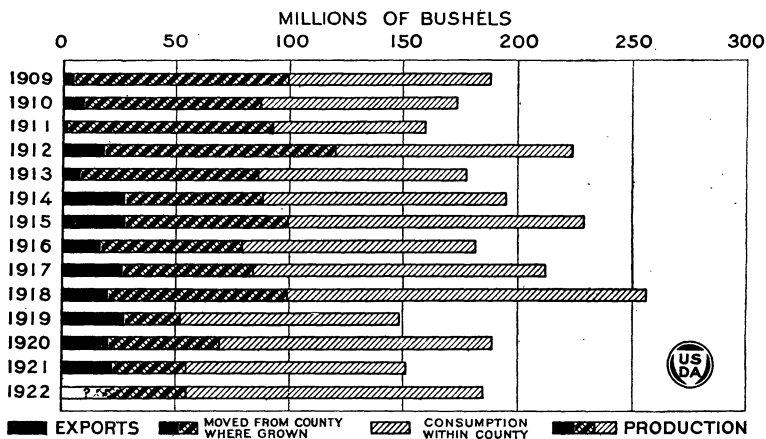


FIG. 17.—Since 1909 the proportion of the barley which moves from the county where grown has decreased steadily, in spite of increased exports, as local consumption for feeding stock has increased.

As transportation of malt was expensive, barley was grown in all sections for a time, regardless of the suitability of local conditions. As transportation facilities improved barley culture was dropped in the less favorable areas and expanded in the more favorable ones. Thus important barley-producing centers developed successively in New York, California, Wisconsin, Minnesota, the Dakotas, and Kansas, as shown in Figures 18 to 25, inclusive.

**Factors Affecting Barley Production.**

*Climate and soils.*—At the present time there is in progress a marked shift in the location of the barley acreage. Changes in the acreage have come about in the past and are now being brought about largely by two factors, namely,

the fitness of barley for certain geographic conditions and legislation affecting the market. The barley plant is adapted to regions of cool summers where the soil is not too sandy, but is well drained. It does not do well on poorly drained soils. It does not do well under humid conditions where high temperatures prevail. Under arid and semiarid conditions it can be grown even in the Tropics if sufficient water is available.

*Acre value.*—Under suitable conditions of soil and climate barley yields more in pounds of feed per acre than any other small grain. These conditions are common to the northern tier of States as far west as the Missouri River and to all of the Western States. Due to the fact that the rough awns of barley make it a disagreeable crop to handle, farmers seldom grow barley unless the returns are manifestly greater than could be secured from a cereal more easily handled or unless a better distribution of farm labor is obtained. In the central valley of California neither wheat nor oats has given nearly as high an average acre return as has barley. In certain sections of this valley barley is a dominant crop for this reason.

*Early maturity.*—A part of the barley acreage of the Dakotas is due to another factor. Barley is a crop which matures quickly, and therefore can be seeded later than spring wheat or spring oats and still produce a satisfactory crop. The highest yields of barley are secured from early seeding. Its quick maturity, however, allows it to be used for late seeding where few other crops could be sown to advantage. A considerable proportion of the crop of North Dakota and South Dakota has always been of this nature.

*Effect of prohibition.*—The most recent factor affecting the production of barley has been the prohibition of brewing. This came at a time when a very fundamental change in barley production was taking place. The high acre yield of barley in pounds of feed was being recognized in the increased acreage of the crop and in the percentage of the crop fed on the farms where grown (see Fig. 17). The percentage of the barley moved out of the county where grown was increasing steadily before the prohibition of brewing. This legislation did not cause any abrupt accelera-

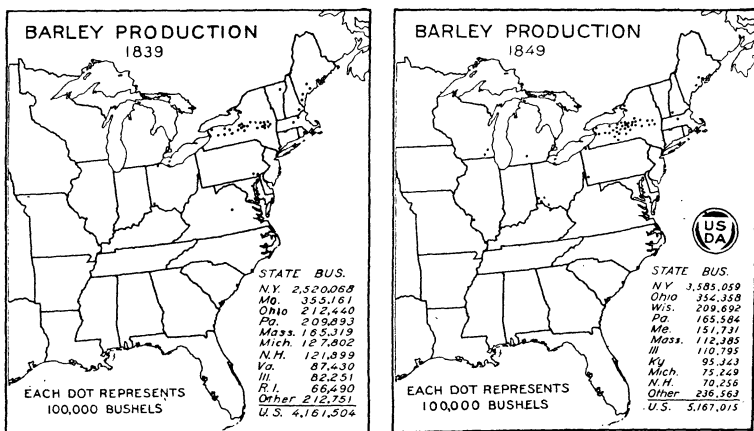


FIG. 18.—In 1839 most of the barley of the United States was produced in New York. The production was heaviest along the line of the Erie Canal. There also was a fringe of production near the coast of New England and a small acreage on the favorable soils of southeastern Pennsylvania. The production of barley in 1849 was still centered in New York State. In the Mississippi Valley a city demand for barley for brewing was reflected in the beginnings of production near Cincinnati, St. Louis, and Milwaukee.

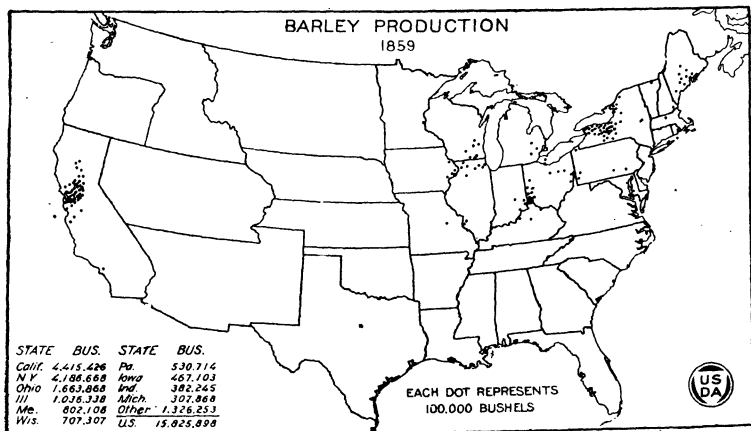


FIG. 19.—By 1859 New York was losing its dominant position in barley production. Production had increased in southwestern Ohio, about Cincinnati, and still more notably in northern Illinois and southern Wisconsin. In this section barley had spread away from the local city market and become a general farm crop. Only a slight increase took place near St. Louis. The settlement of central California, following the discovery of gold, resulted in a production in the State fully as great as that in New York.



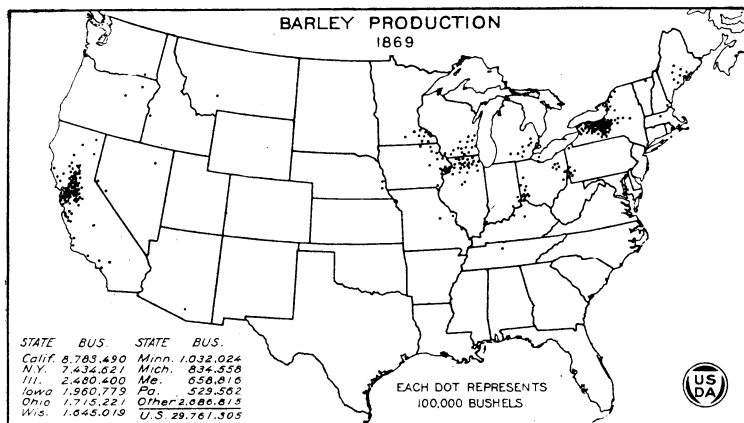


FIG. 20.—In the decade from 1860 to 1869 barley became commonly cultivated in southeastern Minnesota and its culture was begun in eastern Oregon and Washington. There was a notable increase in southern Wisconsin and northern Illinois, and some increase in the southern section of the Great Plains area and in the Mountain States. California and New York, however, remained the most important producing States.

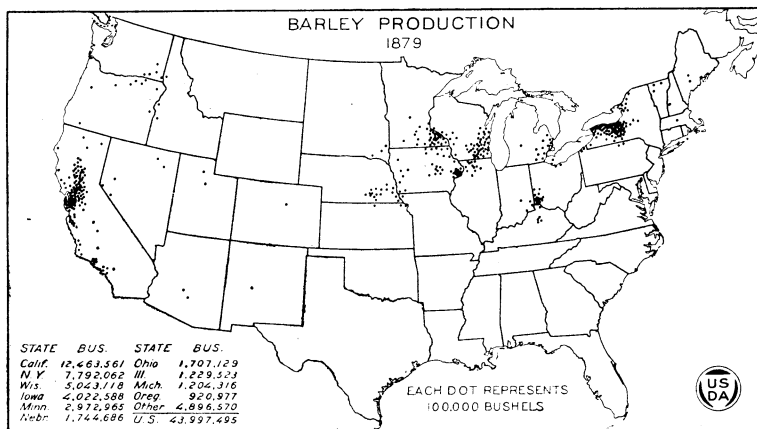


FIG. 21.—In the years from 1870 to 1879 the total production of barley in the United States increased almost 50 per cent. The culture of barley was extended westward into eastern Nebraska and southeastern Dakota. It also became more widely distributed in the Pacific Coast States, while a small production was developing in Utah, Nevada, and Arizona.

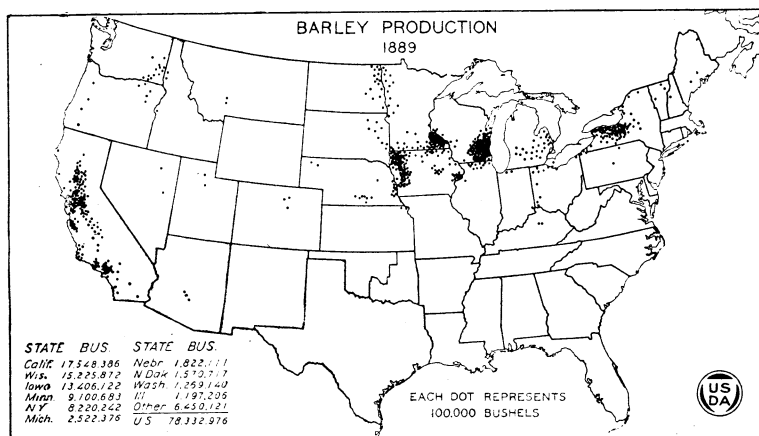


FIG. 22.—By 1889 there was a marked concentration of the areas growing barley for the malting market. On the favorable soils of western New York, southeastern Wisconsin, southeastern Minnesota, and northwestern Iowa, and in the central valley of California barley was grown as a money crop. At the same time production was increasing in the Red River Valley of Minnesota and North Dakota. The production of barley about Cincinnati decreased in the face of competition from the northern Mississippi Valley.

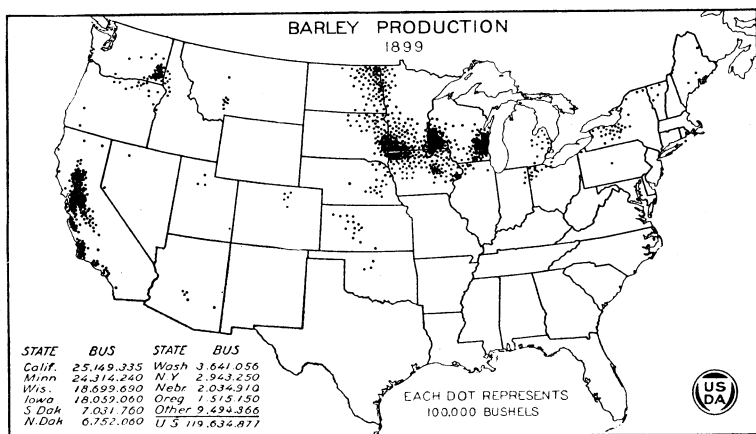


FIG. 23.—In 1890 the tariff on barley was raised to 30 cents per bushel. The malt houses of western New York had been securing part of their barley from Canada, but this tariff made the importation of barley unprofitable. The near-by supplies were insufficient and the malting industry was transferred to Wisconsin and Minnesota. In New York the area devoted to barley decreased after 1890. Production increased notably in Minnesota and California, also in eastern Washington and Oregon, in the Red River Valley, and in the central section of the Great Plains area.

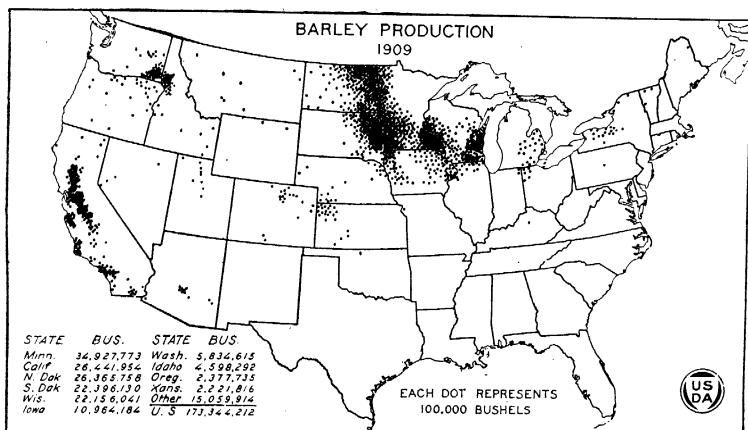


FIG. 24.—The decade ending in 1909 was marked by the rapid expansion of the acreage in the Dakotas and the definite beginning of a center of production in northwestern Kansas. Minnesota was now the leading State, producing, with the Dakotas, almost half of the national crop. California, however, was a close second to Minnesota, with an average production of 29 million bushels in the last five years of this decade.

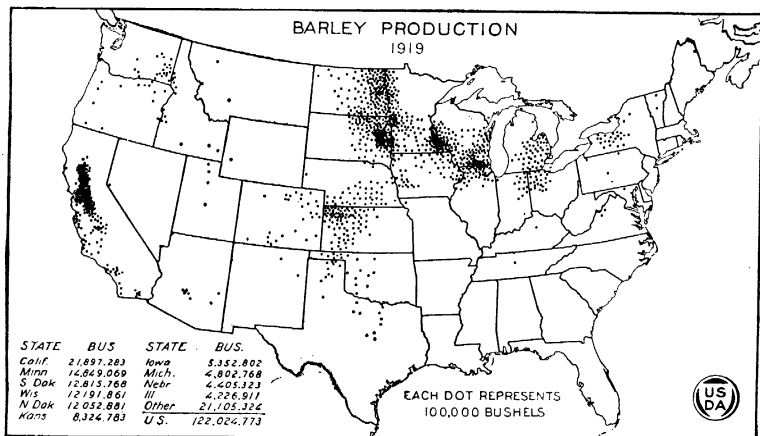


FIG. 25.—The production of barley in 1919 was abnormally distributed. The great increase in the spring-wheat acreage in the Dakotas, coupled with a low acre yield of barley, resulted in a lower production in these States in 1919 than in the years before or since. The decrease in southeastern Minnesota in 1919 was caused chiefly by the gradual drift away from barley as a money crop, a process which had been going on since 1910. The most remarkable development of production was in the central Great Plains area, especially Kansas. This probably is part of a permanent modification of the agricultural practice of the section.

tion of this movement. The effect of the regulation has been less than might have been expected.

The brewers of the United States were using slightly more than 50 million bushels of barley each year at the time when brewing was prohibited. This 50 million bushels, while constituting only about 30 per cent or less of the crop, did cause a premium to be paid for the highest grades of barley. The larger part of the crop, however, was marketed in competition with oats and corn as a feed grain. With the coming of prohibition the market for fancy barley did not disappear. There is still some demand by the malt houses for barley in the making of near beers.

*Foreign demand.*—The export demand also has increased. Before the war Europe imported about three times as much barley from Russia as was used in our malt houses. This Russian supply has been cut off. Our annual exports are possibly 15 million bushels greater than they will be when Russian barley again is available. A part of the present foreign demand has been for high-grade barley, and at present there is a resulting difference in price per pound of fancy and low-grade barley that does not exist in other feed grains. The final effect of prohibition is likely to be a loss of the premium for the fancy grades of barley.

TABLE 2.—*Estimated annual loss of barley from disease, 1917–1921, inclusive.*

Disease.	1917	1918	1919	1920	1921
	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>
Loose smut.....	7,385,000	2,381,000	1,369,000	1,385,000	764,000
Covered smut.....		5,350,000	1,868,000	1,992,000	694,000
Stripe.....	2,212,000	8,802,000	1,898,000	786,000	1,041,000
Stem rust.....	1,991,000	( <sup>1</sup> )	4,368,000	3,628,000	1,704,000
Leaf rust.....		( <sup>1</sup> )	( <sup>2</sup> )	242,000	( <sup>2</sup> )
Other diseases.....	664,000	( <sup>1</sup> )	942,000	1,714,000	5,021,000
All diseases...	12,252,000	.....	10,445,000	9,747,000	9,224,000

<sup>1</sup> No estimate made.

<sup>2</sup> Negligible damage.

*Fungous diseases.*—The most important diseases of barley are covered and loose smuts, stripe disease, and scald. The smuts of barley usually occur to some extent wherever the crop is grown, and may cause losses ranging from a trace

to 50 per cent. They can be prevented by seed treatment. The stripe disease, most prevalent in the northern Mississippi Valley, occasionally causes losses as high as 40 or 50 per cent, but usually much less. Barley scald is important in California, where it may reduce yields very considerably. The most destructive barley diseases and the estimated annual losses they cause are listed in Table 2.

*Insects.*—Barley is subject to periodical heavy infestation by the Hessian fly when grown in the regions where this insect is most abundant; but as the present principal areas of barley production in this country lie outside of the preferred habitat of the Hessian fly, comparatively little general injury from this pest has yet occurred. During the first half of the nineteenth century, when the center of barley culture in this country was in the Northeastern States, great injury was done to this crop by the barley jointworm.

#### Marketing Barley.

As indicated in the discussion of the trend of production in this country, a decreasing proportion of the barley produced in the United States goes to market. For the central producing area Minneapolis and Chicago are the principal central markets.

There are no Federal grades for barley. Grades are in use at certain markets, but they were established by the States or by the exchanges. The grades at the different markets vary in their requirements and therefore are not fully comparable one with another. In Figure 26 the percentage of barley falling into the various grades is given for the Minnesota market for the two years from September 1, 1920, to August 31, 1922, and for the Chicago market for the two years from September 1, 1919, to August 31, 1921.

The barley coming to these markets is almost wholly of the Manchuria type, from the States of the upper Mississippi Valley, except in years of short crop in that area when barley is received from more Western States. These receipts therefore do not indicate the character of the western barley. The two-rowed brewing barleys are not included in the data for the graph, as the receipts of two-rowed barley are insignificant.

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Most of the barley on the Chicago and Minneapolis markets (Fig. 26) falls in grades 3 and 4. On those markets grade 3 allows a bushel weight as low as 44 pounds, a weed-seed and dirt content as high as 3 or 4 per cent, and a maximum of 7 per cent of other grains, which may include 4 or 5 per cent of wild oats.

### Barley Foods, Feeds, and Feeding.

Barley is used for brewing, feeding, and pearling. In composition barley resembles wheat. For human food it

#### BARLEY: ANNUAL VARIATION IN QUALITY.

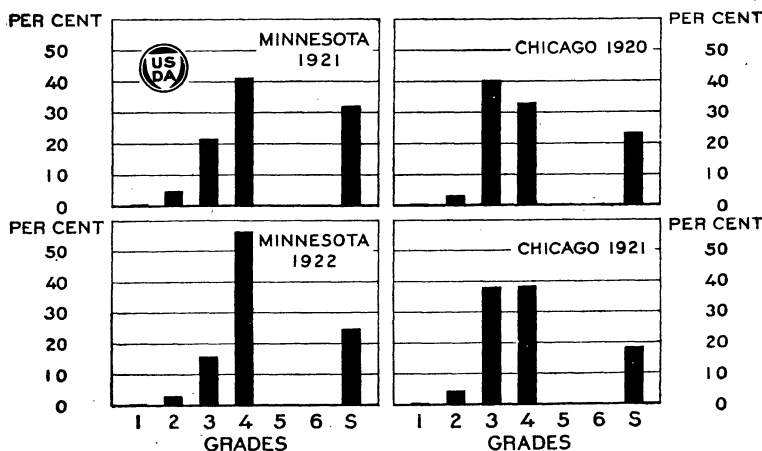


FIG. 26.—Annual quality of barley inspected by the State Grain Inspection Department of Minnesota at several points, chiefly Minneapolis and Duluth, in the two years from September 1, 1920, to August 31, 1922, inclusive, and by the Illinois State Grain Inspection Department at Chicago in the two years from September 1, 1919, to August 31, 1921. In both States most of the barley is graded Nos. 3 and 4 and sample grade.

is used chiefly in the form of pearl barley for thickening soups and for other purposes, and of ground barley for making an infant food. It has some use, also, as a breakfast food. In times of stress, when the use of wheat is restricted, barley is utilized as a wheat substitute in baking, as was the case in this country during the World War.

The by-products of brewing are malt sprouts and dried brewers' grains. The former are not very palatable and are not in great demand, but the latter are one of the best dairy

feeds. The by-products of pearling barley is "barley feed" and consists of the hull, the bran layers, and part of the starchy portion. The by-products of barley are good feeds. The hulls alone have very little feeding value and one should avoid depending too much upon feeds composed chiefly of hulls for satisfactory growth, maintenance, or fattening. Barley fed as a whole grain usually is consumed in sections where it is raised.

Barley generally is considered about 90 to 95 per cent as valuable as corn for fattening live stock (Fig. 27). Although it is a good feed for all stock, it should be crushed or rolled for sheep, hogs, and all young stock. If

#### BARLEY AND CORN FOR FATTENING HOGS.

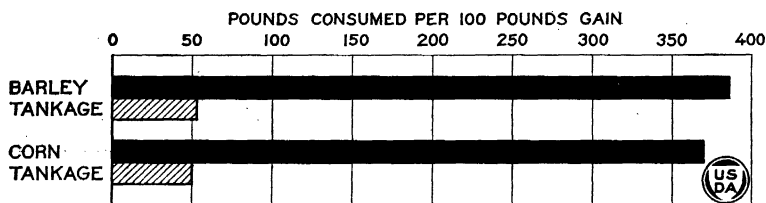


FIG. 27.—This graph is based on the results of two experiments in feeding barley at the Colorado Agricultural Experiment Station, as published in Bulletin 165. In the first experiment, two lots of 10 pigs each, averaging 66 to 70 pounds per head, were fed for 13 weeks on grain, and tankage in the ratio of 10 to 1 by weight. In the second experiment, two lots of 8 pigs each, of similar weight, were fed for 15 weeks on grain and tankage in the ratio of 6 to 1. In some experiments barley has given equally as good results as corn, while in others it has been slightly inferior.

ground fine the flour produced makes mastication difficult and the animals do not like the grain as well and eat less of it than when it is rolled. It should not be the only grain in a heavy ration for young pigs, as the hulls may irritate the digestive system. It is often used in preference to corn for show cattle because it does not make such hard flesh. While it is slightly richer than corn in digestible protein, it also should be supplemented with some protein concentrate or legume roughage.

#### The Situation and Outlook.

The present situation and the future outlook is encouraging. The acreage in California is likely to be maintained because of the high relative yield of barley. The California

barley also is better suited to the needs of European brewers in those countries where the use of malt adjuncts in the manufacture of beer is prohibited.

Barley always will be useful as a late-sown crop in the Dakotas. Recently there has been a marked increase in the acreage sown early as a preferred crop in South Dakota. Barley has been giving a return per acre that has justified its being given the preference in soil preparation and in time of seeding. A decreasing proportion is being seeded later than its optimum season.

The type of farming in southeastern Minnesota has gradually changed from grain farming to combined stock and grain farming and the barley acreage has decreased, as has that in Wisconsin.

In northwestern Kansas there has been a marked increase in the acreage. In this section it has been found that barley yields a very high return as a spring-sown crop. It fits in well with the culture of winter wheat as the acreage can be expanded or contracted to complement the fluctuations of the wheat acreage, especially when winterkilling occurs.

In the Mississippi Valley farmers and feeders generally have not been familiar with the use of barley. Most of the better grades have been marketed and the lower grades have been utilized in mixed feeds or on the farms where produced. The advent of prohibition probably has assisted in the spread of information on the ways of using barley in feeding.

In eastern Canada a large acreage is devoted to the production of mixed grains for feed. The Canadians have found that barley and oats sown together produce decidedly more feed to the acre than either sown alone. This custom is becoming more common in New York State, and the acreage of barley in pure and mixed fields is increasing.

In general, the trend at the present time is toward an increase in the farm use of this grain for feeding stock. The very high acre return is gradually causing a higher appreciation of barley as a feed crop. It seems probable that barley itself will be grown in the future on more farms and over a wider area in the United States, but less extensively in special areas than in the past. It is likely also that the proportion of barley consumed on the farm where grown will continue to increase.



## Rye.

### Importance of the Crop.

Rye is a comparatively unimportant crop in the United States (Fig. 1). It formed less than 1 per cent (0.8) of the total value of the 20 principal crops in 1919, and occupied only 2 per cent of the total acreage of these crops, although about two and two-thirds times as much rye was grown in that year as in any previous census year. The production per capita of the population was less in 1919 than in 1839, and was less than one-tenth that of wheat. In certain areas, however, rye is an important crop. It has recently become quite important in the subhumid lands of the northern Great Plains area. Previously it had been grown mostly in the sandy sections of the Great Lakes States.

### World Production of Rye.

The pre-war world production of rye amounted to about  $1\frac{3}{4}$  billions of bushels annually, or nearly one-half the annual wheat production. Before the World War Russia produced more than one-half the world crop of rye, Germany about one-fourth, and Austria-Hungary nearly one-tenth of the world crop. These three countries combined produced 86 per cent of the total world crop of rye in the five-year period 1910-1914. About 96 per cent of the rye crop of the world was produced and consumed in Europe. During this period the United States produced about 2 per cent of the total rye crop of the world. In the last 10 years rye production in the United States has been increasing.

### Trend of Acreage, Yield, Production, and Price.

The acreage of rye in the United States showed a downward trend from 1867 to 1872 (Fig. 28) and an upward trend from 1873 to 1882. It then remained practically stationary throughout the 31-year period from 1882 to 1912. From 1913 to 1919 a rapid increase in acreage took place because of enlarged European and domestic demand resulting from the World War. The large increases in 1917 and 1918 were 37 and 41 per cent, respectively, of the acreage of the preceding year.

**RYE: ACREAGE, PRODUCTION, ACRE YIELD, AND FARM PRICE, UNITED STATES, 1866-1922.**

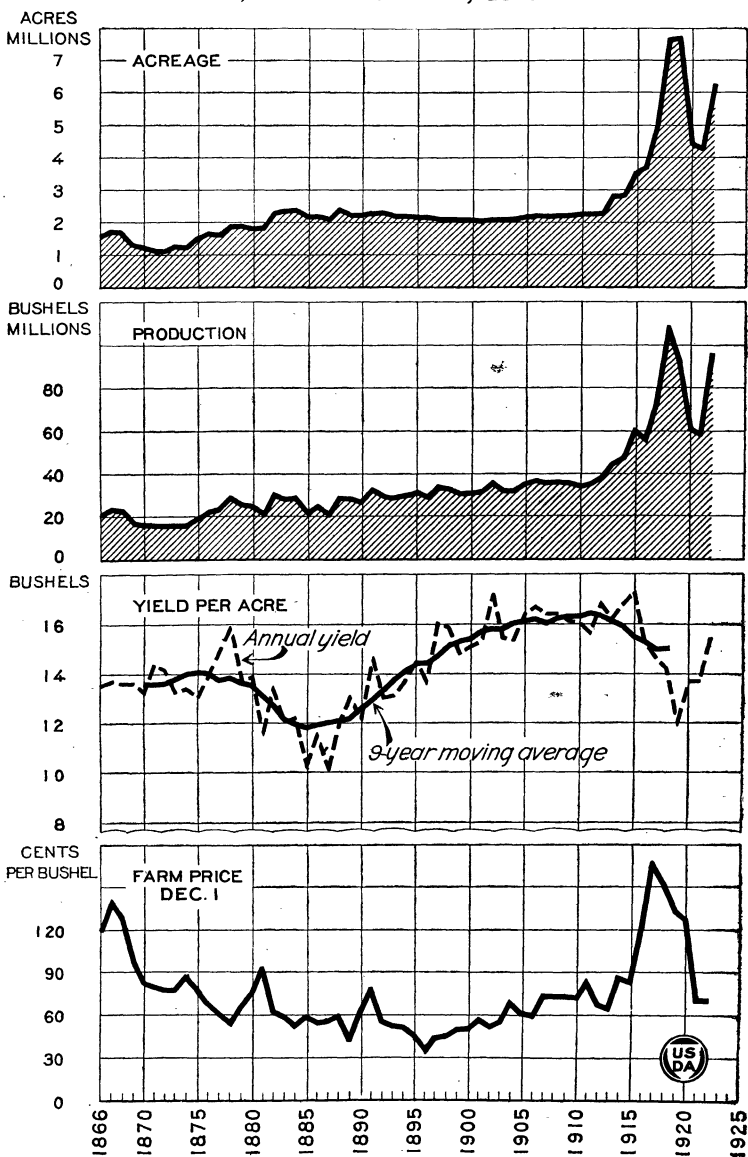


FIG. 28.—Rye acreage decreased for a few years previous to 1872, increased until 1883, then remained fairly steady until 1913, since which time large increases have occurred. Trend of production was upward from 1874 to 1918. Acre yield and farm price show definite upward trends during the 20 years prior to the World War and downward trends since its close.

The production of rye, being the result of both acreage and acre yield, has fluctuated considerably from year to year. A gradual increase was apparent, however, from 1874 to 1911 and a rapid increase from 1912 to 1918. In 1922 the production of 95,497,000 bushels was second only to the record crop of 108,289,000 bushels in 1918.

The acre yield of rye has fluctuated more or less from year to year, the lowest being 10.1 bushels in 1888 and the highest 17.3 bushels in 1915.

### Historical Development of Rye Production.

Rye was brought from Europe to the American colonies by the early settlers. A description of the Bay settlements (Massachusetts) in 1632 or 1633 notes that rye, as well as oats and barley, was grown, and in 1636 it was reported that about 30 plows were at work and much rye was sown with the plow. Wheat appears in the records in 1640. In the records of the Plymouth Colony rye appears in 1640 for the first time, while wheat first appears in this colony in 1642.

Rye was grown by the Dutch settlers of New Netherlands (New York) as early as 1625. The Swedes began to grow rye soon after settling along the Delaware River in 1638. The records show that in the autumn of 1643 they bought 75 bushels of rye seed at New Amsterdam. Rye also appears in the early records of the settlement in Maryland. The Saltsburger colony in Georgia early began to grow rye, it is reported, and a mill was established for making flour.

Rye was apparently of greater importance to the New England colonists than to the settlers farther south. Rye flour and corn meal were their main breadstuffs. Wheat did not do well in New England and wheat flour was not available before the development of the wheat industry in western New York. The earliest agricultural census, taken in 1840, shows very little rye production south of the Potomac River, except in the mountainous sections.

The discussion of the development and shifting of rye production by decades from 1839 to 1919 is given under the maps (Figs. 29 to 35) showing production in each of these census years.

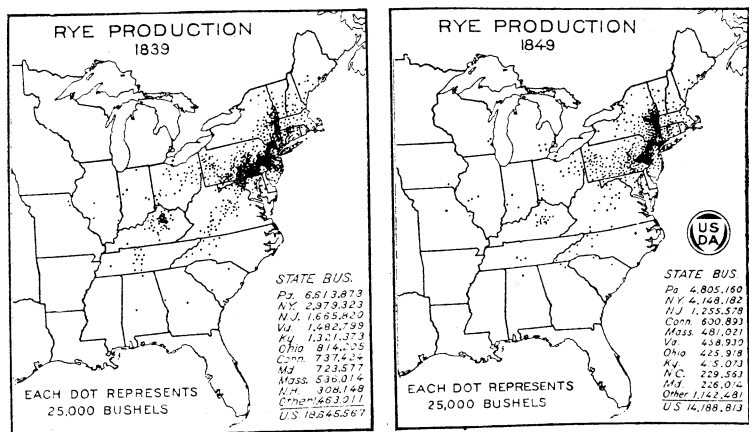


FIG. 29.—In 1839 the production of rye centered in a large district covering southeastern New York, northern New Jersey, eastern Pennsylvania, and central Maryland. Virginia and Kentucky also each produced in excess of a million bushels. A beginning had been made beyond the Mississippi River, in Missouri. The total production in the United States was 18,645,567 bushels. In 1849 the total rye production in the United States was less than in 1839. The center of production had receded from southern Pennsylvania and Maryland. Production had increased in New York but decreases had taken place in the other leading States. Rye growing had extended into Michigan, Wisconsin, and Iowa.

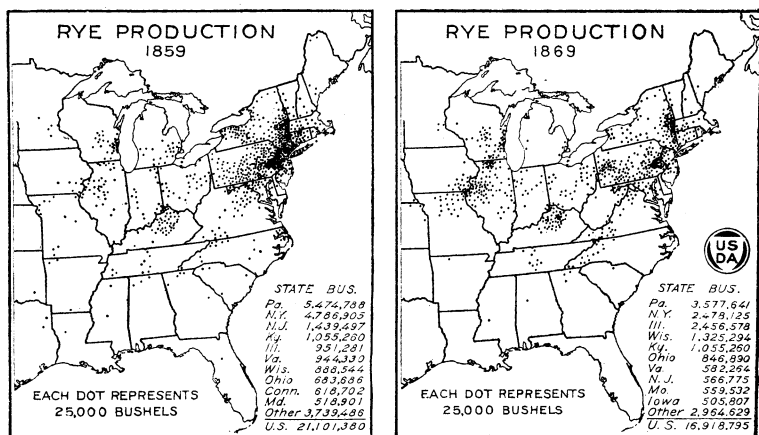


FIG. 30.—The production of rye in 1859 was about 50 per cent greater than in 1849. The center of production remained stationary. Production in Pennsylvania and New York had increased, as had that in Kentucky and several of the Corn Belt States. A considerable increase had taken place in Wisconsin, and a beginning of production had been made in Minnesota, Arkansas, Mississippi, Louisiana, and Texas. Another decrease in rye production was shown to have occurred by 1869. The total production amounted to only 16,918,795 bushels. The decrease was notable in Pennsylvania, New York, and New Jersey, but production had increased materially in Illinois and Wisconsin and to a lesser extent in Ohio, Missouri, and Iowa. Kansas and Nebraska appeared as rye-producing States.

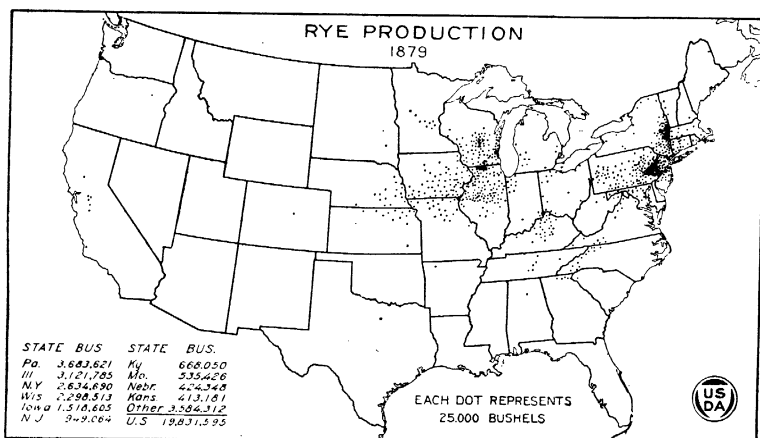


FIG. 31.—In 1879 production had increased somewhat as compared with 1869, but was not yet as large as it had been 20 years earlier. Two widely separated areas of production are apparent. The old center in the East includes parts of New York, Pennsylvania, New Jersey, and Maryland. The new one in the West is located in Wisconsin, Illinois, and Iowa and parts of States adjacent on the west. Production has begun also in several of the far western States.

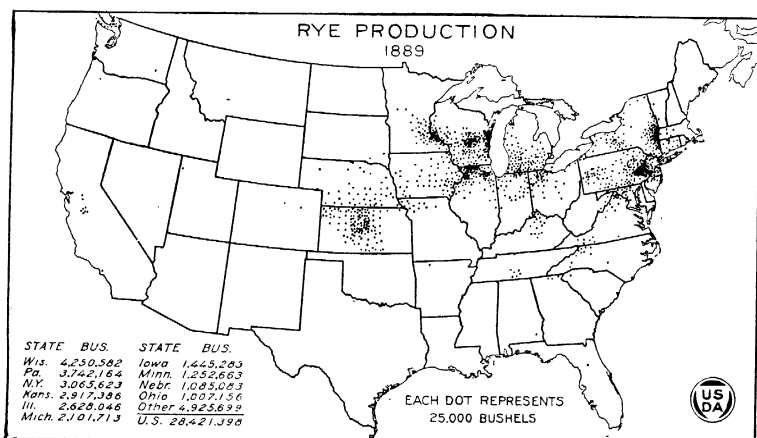


FIG. 32.—In 1889, for the first time in any census year since 1839, Pennsylvania failed to be the leading State in rye production. Wisconsin now led in production, while Pennsylvania had dropped to second place and New York to third. Two new centers of production appear, one in Michigan and adjacent portions of Ohio and Indiana, the other in Kansas and Nebraska. Rye was grown in Kansas because it was winter hardy. The newly introduced hard red winter wheats had not yet crowded out the rye crop.

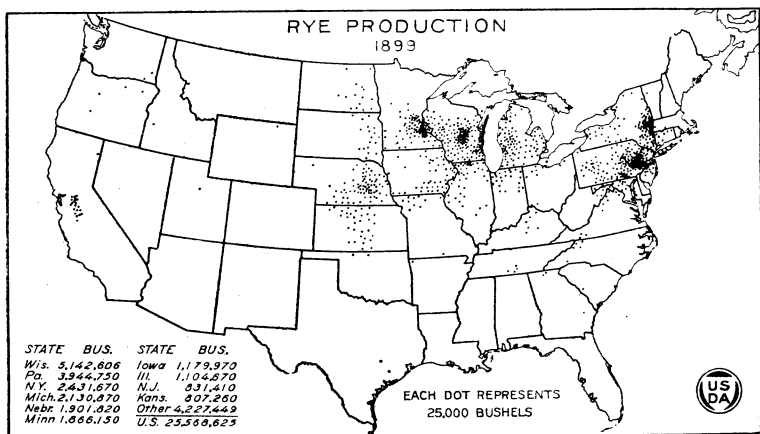


FIG. 33.—In 1899 a decrease in rye production to 25,568,625 bushels had taken place. Wisconsin had increased the lead established 10 years before and now produced more than 5,000,000 bushels. Pennsylvania, New York, and Michigan were still important producers, as were also Nebraska and Minnesota. The production in Kansas had greatly decreased, as the hard red winter wheats were crowding out rye in that State. A beginning of production had been made in North Dakota and a noticeable increase had taken place in South Dakota. In general, the area of production was moving northward.

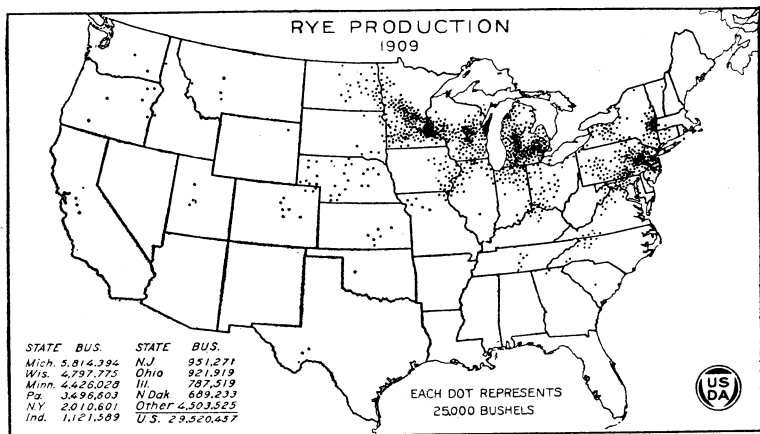


FIG. 34.—In 1909 an intense concentration of production is apparent in Michigan, Wisconsin, and Minnesota. Michigan had become the leading State in rye production. Wisconsin production had decreased slightly, but Minnesota had increased very greatly. Pennsylvania and New York were still important rye-producing States, but the center of production had moved into Michigan and the northern Mississippi Valley. Production in Kansas was very small. The total production of the United States in this year amounted to 29,520,457 bushels.

At the present time rye production is centered largely in the north-central part of the United States. Its production has markedly decreased in the Northeastern States, and it has never gained a strong foothold in the far West.

### Factors Influencing Rye Production.

In any consideration of the bread grains rye must be considered along with wheat. From these two grains is made the light bread consumed by the people of the world. Substitutes can be used, up to a certain point, but the basis of

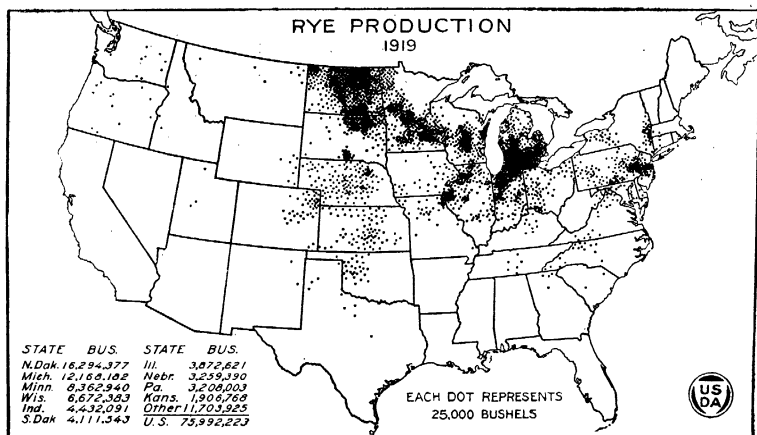


FIG. 35.—The most noticeable shift in rye production that has taken place in any decade since 1839 is revealed by the census figures for 1919. North Dakota has become the most important rye-producing State, the crop of this State alone amounting to more than 16,000,000 bushels. Michigan produced more than 12,000,000 bushels and Minnesota more than 8,000,000 bushels. Production had increased again in Kansas and Nebraska. The total production for the United States was 75,992,223 bushels. Rye now is produced most largely in the sandy and the subhumid parts of the United States.

such mixtures for the production of the light breads must be either wheat or rye flour.

The people of the United States have a decided preference for bread made from wheat flour. This, no doubt, is due in part to the greater palatability of wheat bread, at least according to our standards, and in part to the fact that wheat flour can be worked up more easily and produces more attractive bread, cake, and pastry. As the preference of the American people is not in favor of rye food prod-

ucts, the production of rye is limited, being only about one-tenth that of wheat.

Whenever there is a market demand for rye its production in the United States is largely increased. A marked increase occurred during the war, following an enlarged foreign demand and small crops of wheat and restrictions on the use of wheat in this country. This increased production has persisted to the present year largely on account of maintained foreign demand, the rye crop in 1922 being about double the 1913 crop. This increase in rye sowings is important in its significance as to the place of rye in American agriculture.

From an agricultural point of view there is need for a considerable permanent increase in the production of rye in this country. In many localities rye will give better yields and more food per acre than wheat. In other localities not now growing any bread grain rye will give good yields where wheat would not succeed. There is much sandy land in the southern part of the Cotton Belt that will produce rye successfully, but where climatic and soil conditions make wheat growing unprofitable. In other parts of the country also the rye crop will be more successful than wheat on thin, sandy, and sour soils.

Rye also is hardier than wheat. The rye belt of the United States extends across the country about 300 miles north of the winter-wheat belt (Fig. 35). In the present spring-wheat area of the northern Mississippi Valley winter wheat generally will not survive the winter unless given protection. Rye is the only winter grain hardy enough to withstand these severe conditions. A fall-sown crop is desired, as it distributes labor in both the seeding and harvesting seasons. The rye is largely "stubbled in"—that is, sown in the stubble of other small grain—in the fall and is harvested before the other grains are ready. In the winter-wheat areas generally rye can be sown later than wheat, thus enlarging farm activities.

The risk in growing rye is generally somewhat less than it is with wheat, particularly spring wheat. Rust and hot weather do not affect it so unfavorably and Hessian fly and other insect pests are not so liable to cause damage.



Besides the growing of rye for grain there is a large use of it as winter cover and green manure. Its general adaptability and hardiness make it particularly desirable for this purpose, especially when grown in combination with hardy legumes, like hairy vetch. Much land in the Eastern States is being enriched by use of this combination of cover crops.

*Fungous diseases.*—The most important disease of rye is ergot. It rarely causes any serious reduction in yield, but is always a menace to live stock because of the poisonous effect of the ergot sclerotia or false kernels. The disease can be controlled by sowing ergot-free seed after some other crop than rye, wheat, or barley and keeping down ergot-bearing grasses in the vicinity of the fields.

Other diseases of rye are stem smut, stem rust, leaf rust, anthracnose, and scab. Table 3 presents the estimated annual losses caused by the most important diseases of rye during five years.

TABLE 3.—*Estimated annual loss of rye from disease, 1917-1921, inclusive.*

Disease.	1917	1918	1919	1920	1921
	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>	<i>Bushels.</i>
Smuts.....	471,000	176,000	( <sup>1</sup> )	92,000	60,000
Stem rust.....	471,000	( <sup>1</sup> )	31,000	902,000	98,000
Leaf rust.....		( <sup>1</sup> )	538,000	25,000	112,000
Ergot.....	1,115,000	78,000	( <sup>1</sup> )	214,000	203,000
Scab.....	( <sup>1</sup> )	( <sup>1</sup> )	39,000	( <sup>1</sup> )	( <sup>1</sup> )
Other diseases.....	628,000	( <sup>1</sup> )	964,000	173,000	357,000
Total.....	2,685,000	.....	1,572,000	1,406,000	830,000

<sup>1</sup> No estimate made.

*Insects.*—Rye is freer from general insect injury than either wheat or barley, although subject to occasional infestation by the Hessian fly and jointworm, and to the inroads of grasshoppers and plant lice.

#### Milling and Marketing Rye.

Most of the rye produced in the United States, except that used for seed, is sold as grain, only a small part of the crop being fed to live stock on the farms. In recent years the larger part of the crop has been exported. The produc-

tion in 1919 was 75,483,000 bushels. In the export year ending June 30, 1920, there were exported 41,530,961 bushels. In the year beginning January 1, 1919, 17,693,250 bushels were ground in mills, as reported in the census for that year. The production in 1920 and 1921 was 60,490,000 and 57,918,000 bushels, respectively. In the export years beginning July 1, 1920, and July 1, 1921, the exports were 47,337,466 and 29,903,602 bushels, respectively.

The principal interior rye markets are Duluth, Minneapolis, and Chicago; the principal export markets are New York, Baltimore, Philadelphia, and Galveston. Most of the rye milling is done in Minnesota and Wisconsin, the mills in these States grinding more than half of the rye milled in 1919.

Grades for rye have not been fixed and established by the United States Department of Agriculture, although grades have been recommended and may be put into effect at some future time. Rye has been graded, therefore, in the different markets in accordance with the grades locally in effect. The requirements of these grades have been different in different States or in different markets. It is not possible, for this reason, to compare accurately the quality of rye reaching the several markets.

The moisture content of rye is important in relation to keeping quality, as rye will become musty and go out of condition readily if the moisture content is too high. Foreign material also is important.

#### Rye Foods, Feeds, and Feeding.

Rye closely resembles wheat in composition and in use, as its protein is of a character that permits the use of yeast in making raised bread. Although rye is not extensively grown in the United States, 17,693,250 bushels were ground in all mills in 1919. This produced 2,575,542 barrels of flour. A bread made of rye and corn meal (Indian meal) was much used in pioneer times and still is made commercially, and also as a home product in some parts of the country. A little attention has been given to the manufacture of breakfast foods from rye.

The by-products known as rye middlings, rye bran, and rye feed are much like the wheat by-products of similar

name. Rye and its by-products generally are fed to hogs. The feeding value is approximately from 85 to 90 per cent of that of corn (Fig. 36).

Considerable difficulty is encountered in feeding rye, because it forms a pasty mass when it is moistened in the process of chewing. As hogs sometimes have difficulty in swallowing ground rye, it should be fed with other grain, such as corn or oats. While there is no particular advantage in its favor, it can be fed satisfactorily to horses, cattle, and sheep. Rye should form not more than one-third of the ration. On account of the small size of the kernel, it should be ground before feeding, especially for pigs. Like corn, it needs to be supplemented by a protein feed. Rye is not nearly as palatable as corn, barley, and oats.

#### The Situation and Outlook.

The increase of rye production in the United States since 1912 and the persistence of about a doubled production even since the ending of the war are due in great part to the enlarged foreign demand. European importing countries, shut off from their usual sources of supply in central and eastern Europe, have furnished a market for our increased surplus. The price in comparison with wheat usually has been more attractive to them, which has aided in maintaining the demand. With the resumption of normal agricultural practices and the stabilizing of trade in Europe it is probable that much of our foreign market for rye will disappear. This will result in lower prices in this country, thereby making the crop less attractive to the farmer.

#### RYE AND CORN FOR FATTENING HOGS.

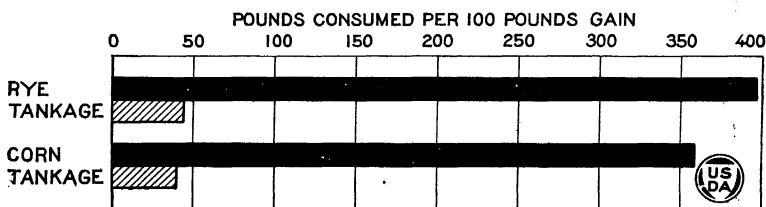


FIG. 36.—This graph is based on the results of an experiment in feeding rye at the Ohio Agricultural Experiment Station, as published in Bulletin 268. Shotes averaging about 70 pounds were fed for 112 days. While the two lots of pigs were not handled in the same way previous to the experiment, the results checked very closely with extensive experiments carried on in Denmark.

With plentiful supplies of wheat, the consumption of rye products is not likely to be largely increased in this country. Our own present domestic use of rye can support only a fraction of our present production. Rye grain is not specially desirable as a feed for live stock, although some of it is fed. It is possible, therefore, that the acreage sown to rye will decrease within the next few years. Some of it is now supported largely by the sale of straw, which is valued for special uses in packing and manufactures.

From an agricultural standpoint it is unfortunate that conditions are not more favorable to the rye crop. There is much land on which it can be grown to advantage, in fact to better advantage than wheat. A dependable market for an enlarged production would assist in establishing a system of agriculture that would utilize our natural resources to better advantage and enlarge the quantity of foodstuffs that we can produce.

## Rice.

### Importance of the Rice Crop.

Among the food grains of the world rice holds a very important place. It forms a large portion of the diet of the people living in the coastal sections of many countries of the Orient, especially in tropical and warm temperate climates. In the United States rice is comparatively unimportant (see Fig. 1) among the cereal crops grown and also in the national diet.

On portions of the Coastal Plain of the South Atlantic and Gulf States rice is the most important grain crop grown. It is important in these areas because it can be more profitably grown on these low lands than any other crop for which there is a market in the United States. In southwestern Louisiana and southeastern Texas rice is almost the only source of income. In some of the parishes and counties in this district over 75 per cent of the cultivated land is used for rice growing.

### World Production of Rice.

Rice is cultivated in all tropical countries, but the greater part of the world crop is grown in eastern and southeastern Asia (Fig. 37), including the larger near-by islands, espe-

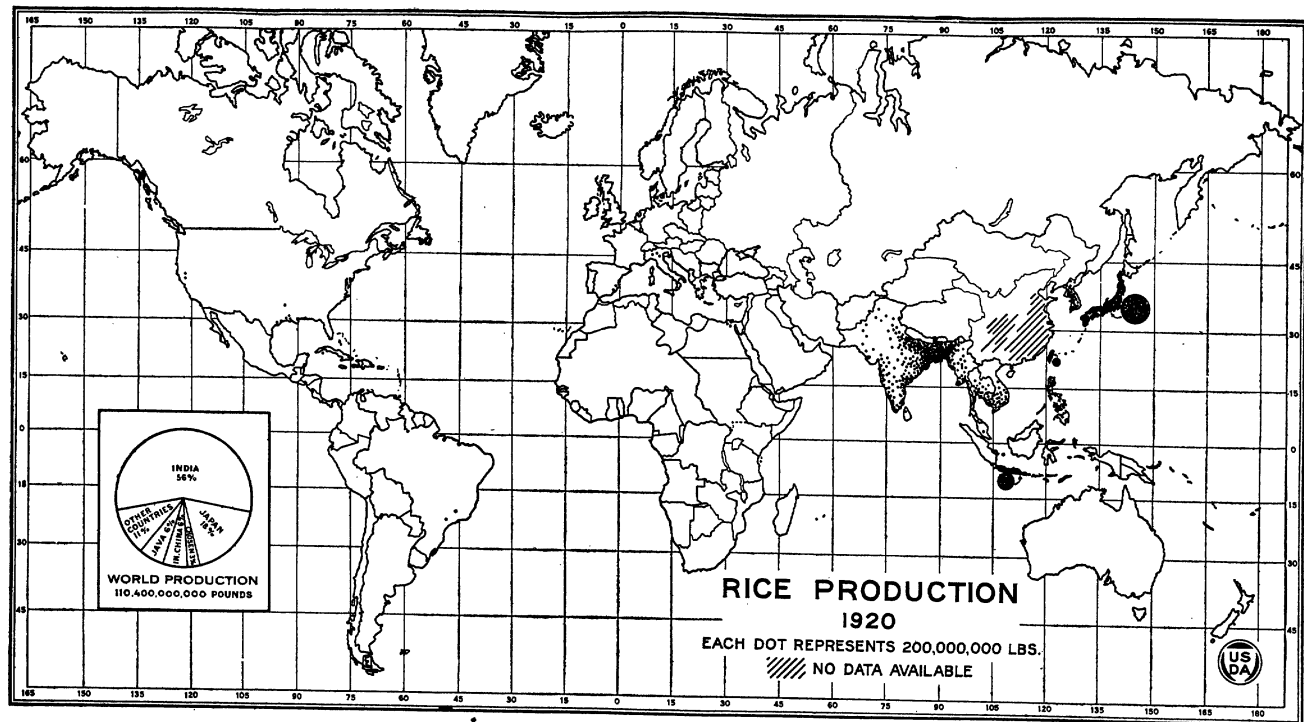


FIG. 37.—Most of the rice crop is grown in the tropical and subtropical countries of the Eastern Hemisphere. The greatest centers of production are in eastern and southeastern Asia and near-by islands, especially Japan and Java. India alone produces over half of the rice of the world, excluding China. The United States has contributed about 1 per cent of the world production since 1918.

cially Japan and Java. The principal producing countries are India, Japan, and China, but statistics for China are not obtainable. Large quantities are produced also in Java, Indo-China, Siam, and Korea (Chosen). These seven countries produced about 90 per cent of the world crop in 1920. Outside of Asia, the principal warm-temperate areas of production are in the United States, Spain, Italy, and Egypt. Of these four, the United States produces the most, having contributed about 1 per cent of the world production in the last three or four years.

The average annual production of rice in the world, excluding China, in the 22-year period from 1900 to 1921, inclusive, has been approximately 108 billion pounds, or 54 million tons, of cleaned rice. In 1901 the production was as low as 94 billion pounds and in 1909 as high as 127 billion pounds. British India produced from about three-fifths to two-thirds of the rice of the world, excluding China, in this period, the extremes since 1900 being 57 per cent in 1918 and 72 per cent in 1902.

During the period from 1900 to 1921 the annual production of British India was approximately 70 billion pounds, or 35 million tons of cleaned rice. The Japanese Empire ranks second, having produced in the last 22 years about 20 per cent of the world's production, excluding China, and has had since 1904 an average annual production of 20 billion pounds of cleaned rice. Java (including the adjacent island of Madura), which ranks third, usually produces annually from 7 to 8 billion pounds. French Indo-China and Siam, ranking fourth and fifth, respectively, in production, supply large quantities of rice for the world trade. Many of the other rice-producing countries within the Tropics depend upon outside sources for the full supply of their needs.

#### Trend and Historical Development of Rice Production.

The annual production of rice in the United States has increased in the last 100 years from about 60 million pounds of cleaned rice to more than 1 billion pounds.

Rice production began in the South Carolina colony as a result of an experimental sowing of rice in the Governor's garden in Charleston in 1694. During the colonial period

of our history the population was too small to consume much of the crop. There was, however, a ready market for it in England, to which country the greater part of the crop was exported. As early as 1712 over 3 million pounds of cleaned rice were shipped abroad. This export trade increased in volume until the Revolutionary War, reaching a total of 76 million pounds of cleaned rice in 1770. The foreign trade, which again increased after the Revolutionary War, began to decline in 1794 as the domestic use of the crop increased.

In 1839 about 90 per cent of the rice was grown on tidal lands of South Carolina, North Carolina, and Georgia. South Carolina produced over 70 per cent of the crop, while Louisiana contributed less than 4 per cent of the production. By 1849 the total production was greatly increased. South Carolina, North Carolina, and Georgia still led in production, though there was a marked increase in Mississippi, Alabama, and Florida. The striking feature is the great increase in production in the areas already used for rice culture. As late as 1859 South Carolina, North Carolina, and Georgia produced 90 per cent and South Carolina alone produced over 60 per cent of the crop.

The production of rice in the South Atlantic States was greatly affected by the Civil War. On account of the destruction of property and the scarcity of money and labor, only a small part of the old plantations could be cultivated. In these States the growing of rice became less profitable each year because of the lack of funds to finance the new plantation management which had become necessary by the changed labor conditions.

In part because less labor was required for rice than for sugar cane, the rice acreage along the Mississippi River in Louisiana began to increase rapidly after the Civil War. The crop did not become important in Louisiana, however, until it was definitely determined in 1887 that rice could be grown profitably on the prairies in the southwestern part of the State. These tracts of land were level and broken here and there by sluggish streams from which irrigation water could be obtained. The irrigation companies that soon were organized to sell and distribute this water gave such an impetus to the growing of rice in this region that

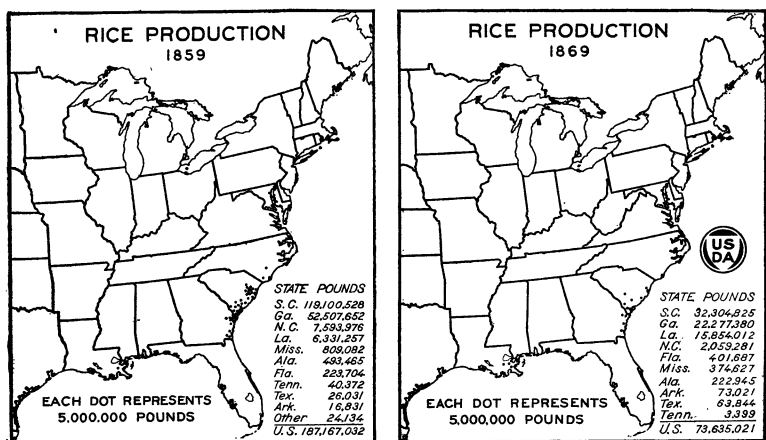


FIG. 38.—The principal producing areas in 1859 were in the tidal sections of South Carolina, Georgia, and North Carolina. The maximum production of Georgia was reached about this time. Outside these three States production had decreased everywhere except in Louisiana. The production of rice in the decade from 1860 to 1869 was greatly affected by the Civil War. On account of the destruction of property and the scarcity of money and labor, only a small part of the old plantations could be cultivated. In 1869 rice production was less than in 1839.

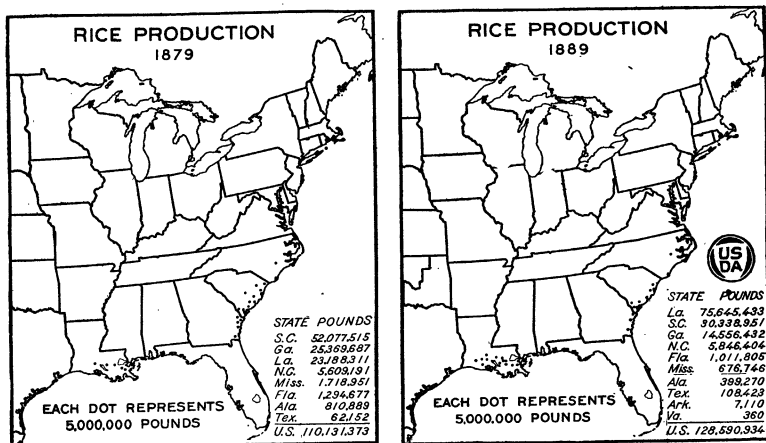


FIG. 39.—While production in 1879 was 50 per cent greater than in 1869, the rice crop was becoming less profitable because of the lack of funds to finance the new plantation management, which had become necessary by the changed labor conditions resulting from the Civil War. Production was just beginning on the prairies of Louisiana. The map for 1889 shows the first great shift in rice production. The extension of a railroad into southwestern Louisiana opened to settlement a vast area of level prairie land, which was abundantly supplied with fresh water and well suited to rice culture. Louisiana had become the leading rice-growing State, producing about 60 per cent of the total crop, while production in South Carolina was beginning to decline.



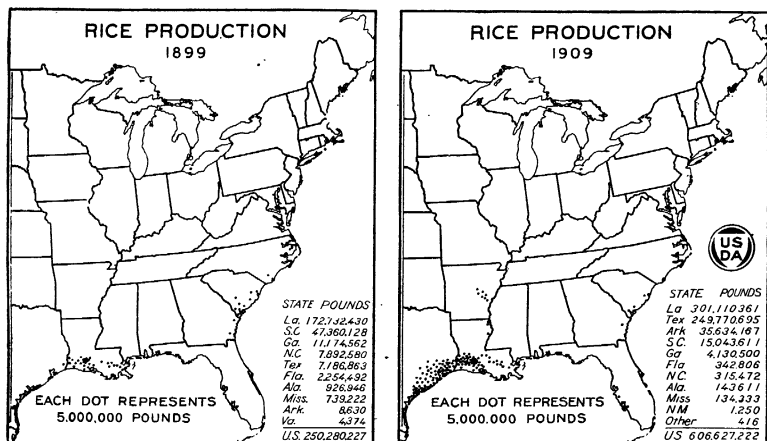


FIG. 40.—The coastal prairie of southwestern Louisiana and southeastern Texas became the center of rice production in the decade from 1890 to 1899. In 1899 about 70 per cent of the rice was produced in Louisiana. Production in South Carolina had increased again. By 1909 production had increased greatly in the prairie rice districts of Louisiana and Texas. In that year these two States produced about 90 per cent of the rice grown in the United States. Arkansas had become a rice-producing State, while production in South Carolina had notably declined.

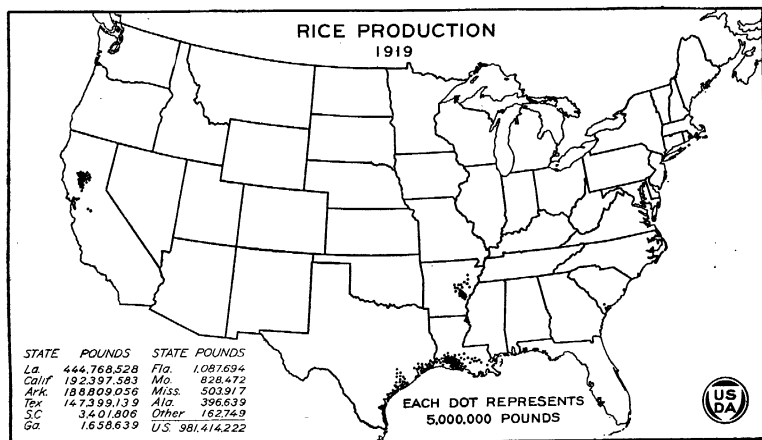


FIG. 41.—The center of rice production in 1919 remains in Louisiana and Texas, but Arkansas has greatly increased its acreage and production. Rice growing became an important industry in the Sacramento Valley of California during the decade from 1910 to 1919. Commercial production began in 1912, and in 1919 California ranked second in production. The production in South Carolina has almost vanished.

in 1889 Louisiana became the leading rice-producing State, which rank it still holds. The successful outcome of this agricultural venture led to the development of similar lands for rice culture in southeastern Texas and eastern Arkansas.

The first commercial crop of rice was grown in California in 1912, principally in the vicinity of Biggs, in Butte County. The greater part of the present acreage is on low land that lies within the counties of Colusa, Glenn, and Butte, and is irrigated mainly from the Sacramento and Feather Rivers. In 1922 California ranked fourth in rice acreage and second in production.

Maps showing the shifts in production by decades from 1859 to 1919 are presented as Figures 38 to 41, inclusive, with the necessary discussion.

#### Natural Factors Influencing Production.

The principal physical factors affecting rice production are irrigation water, precipitation, temperature, and soil, and of these irrigation water is the most important.

*Irrigation water.*—The rice crop is dependent upon an abundant supply of fresh water, for irrigation means the submergence of the land upon which the crop is grown. A depth of approximately 6 inches of water must be maintained throughout a period of at least 75 days. Water, therefore, is required in large quantities and must be available at all times during the growing season to insure maximum production.

*Precipitation and temperature.*—The expansion of the rice area is limited by rainfall and temperature. The crop requires a relatively high humidity and a mean temperature above 70° F. during a growing season of 4 to 6 months. A precipitation between 50 and 60 inches well distributed throughout the year within the rice area and upon the watershed of its streams is an important factor in rice production, as the amount of the available irrigation water is dependent upon it. In Louisiana the rainfall during the growing season furnishes about 20 acre-inches and the remaining 28 inches of the 4 acre-feet of irrigation water usually considered necessary are obtained by pumping.

*Soil.*—Rice is most productive on soils that are medium to rather heavy in texture. These types of soils, however, to be useful for rice production must lie in level tracts and be underlain by a subsoil that is impervious to water. These conditions are necessary to hold the irrigation water within the levees at the required depth.

*Diseases of rice.*—Two of the most important diseases of rice in the Southern States are “straighthead” and “rotten-neck.” Straighthead is a nonparasitic disease caused by the lack of sufficient aeration of the root systems of rice plants growing in soils filled with certain types of organic matter. These plants fail to develop the normal root system. The disease can be controlled by a simple change in the methods of irrigation.

Rotten-neck is a fungus disease which is more prevalent and probably more destructive than straighthead. No satisfactory methods of control are known yet. Seedling blight and stem rot are sclerotial diseases of rice of considerable importance.

*Insects.*—The principal insect enemies of the growing rice crop are the rice water-weevil (*Lissorhoptrus simplex* Say), the immature stages of which feed on the roots; the stink bug (*Oebalus pugnax* Fab.), which sucks the juice from the growing kernels; the rice stalk-borer (*Chilo plejadellus* Zincken), the larva of which tunnels and kills the stem; and the southern grass worm (*Laphygma frugiperda* S. & A.), which eats the leaves.

### Milling and Marketing of Rice.

Rice, like the other small grains, is sown with a grain drill, cut with a self-binder, and thrashed with a grain separator. It is thrashed from the shocks and put in burlap sacks at the separator. The sacks used in the prairie rice districts of the South hold approximately 200 pounds of paddy or rough rice, while those used in California hold about 100 pounds.

Thrashed rice still is inclosed in the hull or chaff. It is known as paddy or rough rice, and in this condition is sold to the rice mills, either through a cooperative selling association or to buyers representing the mills.

Most of the mills are located in the centers of rice production, but some of them are outside of the rice area. In the mills rice is prepared for the market by removing the hulls and the bran and by polishing the kernels, which sometimes also are coated with glucose and talc. The unbroken kernels of milled or cleaned rice are known as head rice. This always commands the highest price. The December mean wholesale price of cleaned rice of the Honduras variety at New Orleans and the December 1 average farm price of paddy or rough rice of all varieties in the United States for the years 1904 to 1922, inclusive, are shown in Figure 42.

**WHOLESALE PRICE OF CLEANED RICE AND FARM PRICE OF PADDY.**

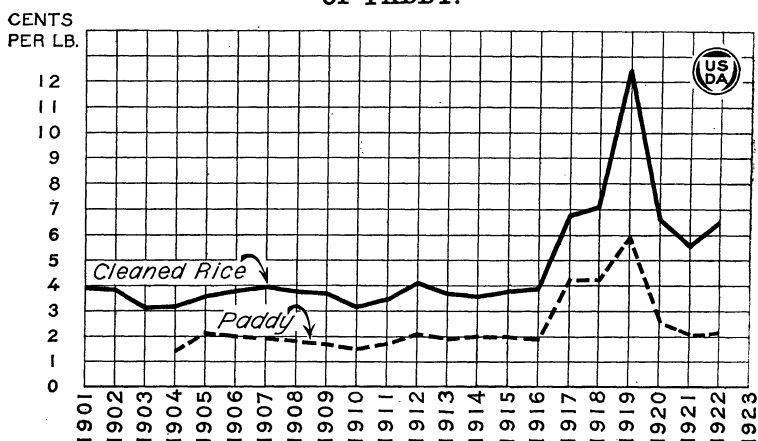


FIG. 42.—The trend of the December mean wholesale price of Fancy grade cleaned Honduras rice from 1901 to 1922 is compared with the average December 1 farm price of paddy of all varieties grown in the United States from 1904 to 1922. In general, the spread in price is fairly uniform except in 1920. Honduras always sells above other varieties of rice, and hence the spread shown is greater than that between paddy and cleaned rice of other varieties.

The marketing of milled or cleaned rice is greatly facilitated at present by the grades proposed in 1920 but not yet established under the United States grain standards act. These grades are known as extra fancy, fancy, choice, medium, and sample grade, and are applied to each of three types of rice grown in the United States, namely, long, short, and round kernels. They are based mainly on color and on percentage of whole kernels (head rice), foreign ma-

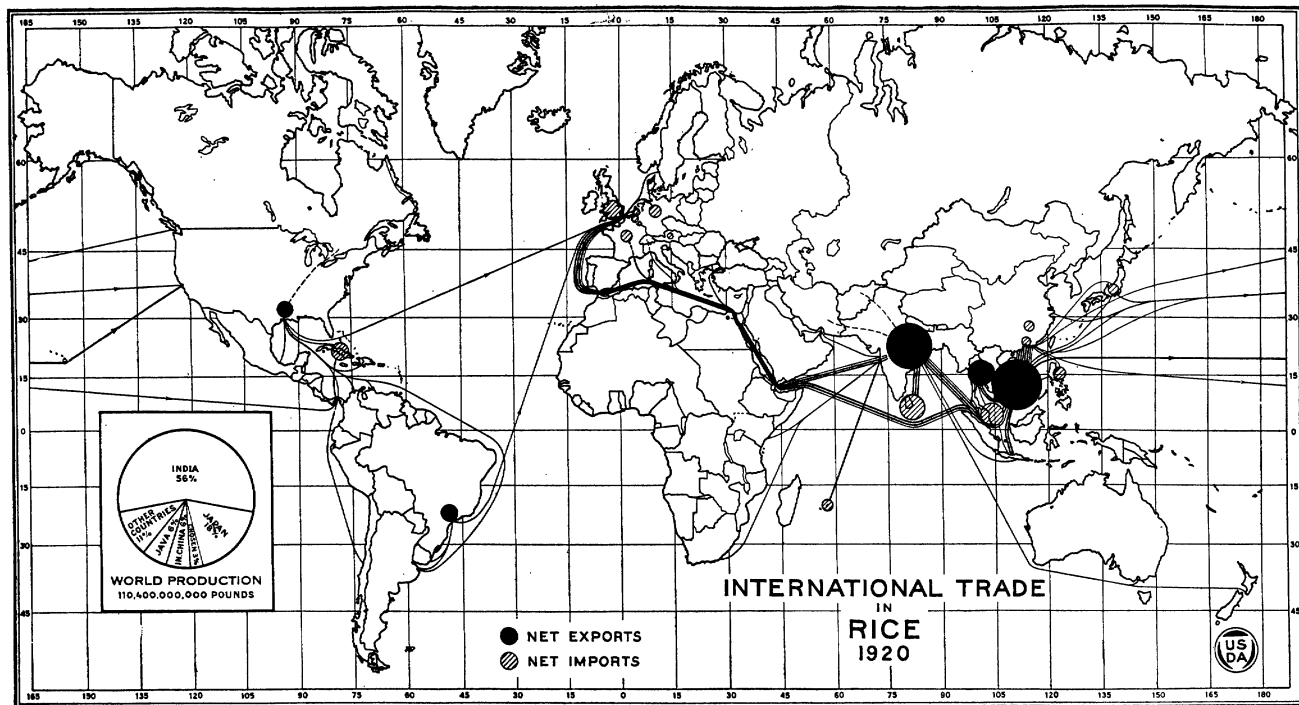


FIG. 43.—The international trade in rice is mainly among the large rice-producing and rice-consuming countries of the Orient. These countries also export large quantities of rice to Europe and the Western Hemisphere. Among the nonproducing countries Great Britain is the largest purchaser. The United States sells rice to Europe, the West Indies, the Central and South American countries, and, since 1921, to Japan.

terial, and moisture. The milled, cleaned, or table rice gets into the general trade through brokers and jobbers.

### International Trade in Rice.

The greater part of the world's exports of rice are supplied by French Indo-China, British India, and Siam (Fig. 43). During the seven-year period 1914 to 1920 British India contributed an average annual net export of 3.5 billion pounds of cleaned rice, French Indo-China 2.75 billion pounds, and Siam 1.9 billion pounds.

Burma, the chief rice-producing Province of India, and Siam supply Europe and the Western Hemisphere with rice of special qualities. Much of the highly milled and polished rice that is produced in the European mills is obtained from these countries. Siam and Indo-China furnish very largely the cheap rice that is needed to feed the native population of the greater part of the Orient, except India.

The principal nonproducing country which imports rice is Great Britain. A group of countries which in pre-war years had lower import requirements includes France, Holland, Germany, Russia, and Cuba. Among the principal rice-producing countries, exclusive of China, the Dutch East Indies ranks first in the imports of rice. Japan, ranking second in production, also imports large quantities of rice to feed a population having the largest per capita consumption of rice in the world.

As early as 1712 the South Carolina colony exported 3 million pounds of cleaned rice. This trade increased in varying quantities (Fig. 44) until 1859, when 81 million pounds were exported. No large permanent increase occurred until 1885. In 1884 the exports were only 168,827 pounds. The average exports for the five-year periods from 1886 to 1920 increased from 482,432 pounds for the period 1886-1890 to 454,000,000 pounds for the period 1916-1920, reaching the maximum annual export of 738,000,000 pounds in 1921. The average annual exports for the 10 years preceding the World War were 129 million pounds of cleaned rice, of which over 80 per cent went to Porto Rico. Of the total export of 738 million pounds in 1921, Porto Rico, Hawaii,

and Alaska received only about 28 per cent, the greater part going to Europe. Japan purchased as much as 56 million pounds.

Rice was imported into the United States for the first time in 1861, when 52 million pounds were brought in. Imports increased thereafter in greatly varying quantities

**AVERAGE RICE PRODUCTION, CONSUMPTION, EXPORTS AND IMPORTS, UNITED STATES, BY 5-YEAR PERIODS, 1821-1921.**

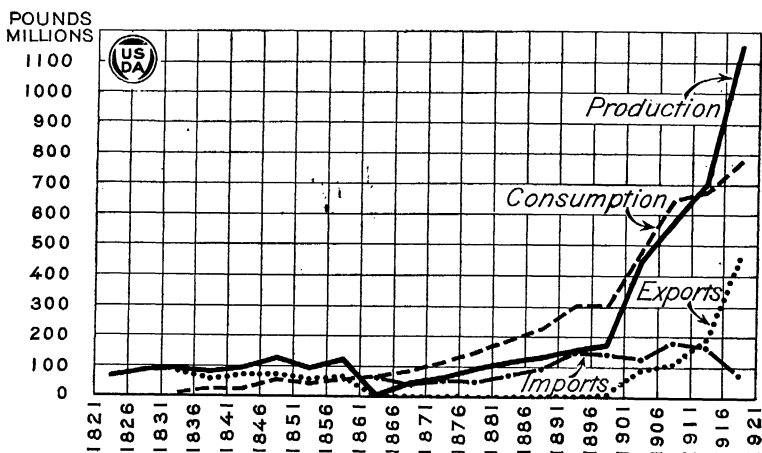


FIG. 44.—The average production of cleaned rice for five-year periods has increased steadily since 1821, except during the Civil War. Consumption exceeded production from 1861 to 1914, except in 1904 and 1911. During and since the World War production of rice has greatly increased, averaging now over one billion pounds annually. Exports also have greatly increased, reaching the maximum of 738 million pounds in 1921.

until the maximum import of 236 million pounds occurred in 1913. After that year there was a constant decline to 1921, when the imports amounted to less than 13 million pounds. In the early years imports were largely for domestic consumption. In recent years they have included the highly milled rice from Europe and also brown rice from the Orient to be milled here and reexported.

#### Rice Foods, Feeds, and Feeding.

Rice, like wheat, is used almost entirely for human food. It has a higher carbohydrate content and less fat than wheat. Its most common use is as a starchy food to accompany meats and similar dishes. It is used also for puddings, for

thickening soups, and in many other ways, commercially and in the home. Puffed rice and boiled rice are common breakfast foods. The kernel also can be popped. Whole or brown rice contains a higher percentage of vitamin and mineral matter than ordinary highly polished rice.

The by-products are important feeding stuffs in Louisiana, Texas, Arkansas, and California, where most of the rice crop is raised. These by-products are rice hulls, rice bran, and rice polish. The hulls have practically no feeding value, but the other two by-products are very nutritious. Owing, however, to the high fat content they easily become rancid and so do not keep or ship well. The bran to be of good quality should contain only a very small percentage of hulls.

#### RICE BY-PRODUCTS AND CORN FOR FATTENING HOGS.

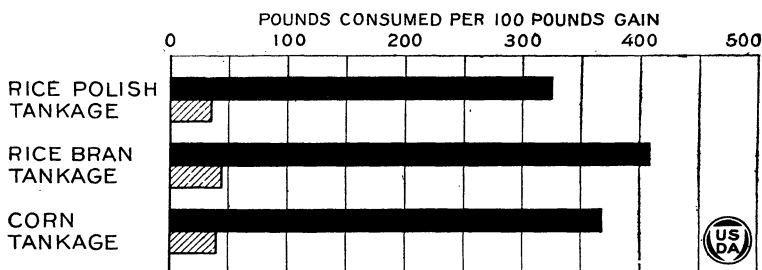


FIG. 45.—This graph is based on the results of three experiments in feeding rice by-products at the Arkansas Agricultural Experiment Station, as published in Bulletin 128 of that station. In the first experiment three lots, each containing 6 shotes, averaging 136 pounds each, were fed for 75 days. In the second experiment three lots of 6 shotes, averaging 85 pounds each, were fed for 82 days. In the third trial three lots of 5 shotes, averaging 75 pounds each, were fed for 84 days. In all three experiments the pigs required fewer pounds of rice polish than of corn to make 100 pounds of gain. In another experiment, without any protein supplement, fewer pounds of rice bran than of corn were required to produce 100 pounds of gain.

Rice seldom is used for live stock in the form in which it is harvested, unless there is a surplus or damaged crop. The rough rice or paddy is a fairly good feed for fattening cattle. However, on account of its hard fibrous hull, rolling or crushing greatly improves its value for live-stock feed.

Rice polish and rice bran are very good feeds for fattening hogs when used with a protein supplement (Fig. 45). Rice polish is probably the most satisfactory rice by-product for feeding hogs. Both rice polish and bran are suitable cattle



feeds, but are not used to any extent in feeding horses and sheep. They are used chiefly in the districts where rice is produced.

### Grain Sorghums.

The grain sorghums comprise several groups, each having a different name and each containing several varieties. The different groups are closely related botanically, and are similar in general appearance and in culture and use. The principal groups are kafir, milo, and durra, the latter including feterita.

#### Importance of the Crop.

In comparison with most of the principal cereal crops and some other widely grown crops of the United States (Fig. 1) the grain sorghums are not very important. These crops are of tremendous importance, however, in the southern section of the Great Plains area, comprising portions of Kansas, Oklahoma, Texas, and New Mexico (Figs. 46-47). In fact it scarcely would have been possible to develop farming enterprises in much of that territory without them. In this section they take the place occupied by corn in the more humid sections of the country. They are the tilled grain crop in the rotation, and they provide the feed grain and roughage for farm and range live stock and silage for the dairy and the beef industries. Because of insufficient rainfall and drying winds it is not possible to grow corn in this territory to supply these needs.

#### World Production of Grain Sorghums.

There are three great centers of sorghum production in the Old World, namely, Africa, India, and Manchuria-China, with a smaller center in western Asia, including Turkestan, Mesopotamia, Syria, and parts of Asia Minor.

In much of Africa varieties of grain sorghums are the staple cereal crops of large numbers of the native population and have been so from time immemorial. The number and diversity of varieties is known to be enormous. The kafir varieties came from Natal, while our feterita came from the Egyptian Sudan. Our white durra and brown

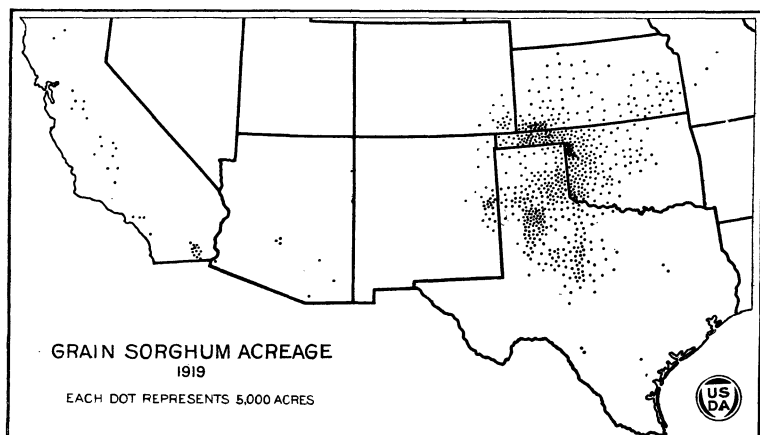


FIG. 46.—Grain sorghums are grown only in the Southwestern States, principally in Kansas, Oklahoma, and Texas. Compare with Figure 47, which shows corn acreage in the same States in 1919. The grain sorghums are grown mostly where climatic conditions are too hot and dry for corn.

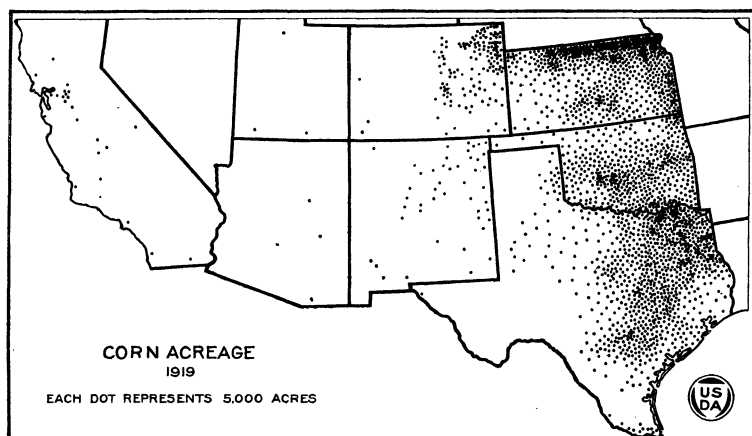


FIG. 47.—Corn acreage in the Southwestern States is confined mostly to the subhumid portions of Kansas, Oklahoma, and Texas. The growing season in northwestern Kansas and northeastern Colorado is too short and cool for the grain sorghums, but corn succeeds fairly well.

durra are found in Morocco, Algeria, and Tunis, while varieties which probably are the original forms of our yellow milo and white milo are found in Egypt.

In India the grain sorghums are of tremendous importance in the drier portions of the interior not suitable for wheat growing. The principal centers of production are in the Bombay and Madras Presidencies and in Hyderabad. The area grown annually is more than 25,000,000 acres. The grain serves for human food and animal feed, and the stalk is utilized for fodder. The crop is known as jowar or juar.

In Manchuria and China is grown an entirely different group of sorghums known as kaoliang. In these countries they are important articles of human diet, as well as feeds for live stock and poultry. With the characteristic thrift of the Chinese and related peoples, every portion of the plant is used in some way.

Occasionally shiploads of kaoliang grain are received at Pacific coast ports of this country, where they enter trade as feed for poultry and stock. Still more rarely occasional shiploads of kaoliang, or of jowar from India, arrive at our Atlantic ports, where they find a similar use. Probably most of these cargoes are brought in largely as ballast rather than as regular freight.

#### Historical Development of Production in the United States.

Different varieties of grain sorghums were introduced at intervals from early colonial times, but none persisted in cultivation. Of the varieties now grown in this country, the earliest arrivals were the white durra and brown durra, which were introduced from Mediterranean Africa to California in 1874 and still are grown there sparingly under the name of "Egyptian corn." About 1879 the white variety appeared in Kansas under the name "Jerusalem corn," but whether from California or direct from Syria is not known. At about the same time there was grown sparingly in Kansas a similar variety known as "rice corn," which probably was the present white milo.

In 1876 the Centennial Exposition was held in Philadelphia. The exhibit of the Orange River Colony of South Africa contained the seeds of two varieties of kafirs,

a group of grain sorghums grown by the Kafir tribes in Natal. A thimbleful of this seed reached the State commissioner of agriculture in Georgia in 1877 and by him was sent to Dr. J. H. Watkins, of Palmetto, Ga. He grew and selected the plants until 1885, when he distributed some seed. In 1886 larger quantities were distributed by him and through the Georgia State Commissioner of Agriculture and the United States Commissioner of Agriculture. The crop became established in Kansas in about 1888.

About 1885 the sorghum now known as yellow milo was brought to notice in South Carolina or Georgia and in 1887 it was widely advertised. It soon became established in the drier parts of Texas.

No complete annual statistics on grain sorghums in the United States are available until 1915, though census data were obtained in 1909. Kansas reported 47,000 acres of kafir in 1893, and three-fourths of a million acres of all grain sorghums 10 years later in 1902. No further increase took place until 1911, when over 1 million acres were grown in Kansas. Oklahoma reached the million-acre basis not long afterwards.

The trend of acreage, acre yield, production, and farm price for bushel for the eight years from 1915 to 1922, inclusive, is shown in Table 4 with the data for 1909 for comparison. The grain-sorghum crop is holding its own with an average of about 5 million acres annually.

During the last three years the three important producing States in order of acreage are: Texas, with nearly 2 million acres; Oklahoma, with  $1\frac{1}{2}$  million acres; and Kansas, with 1 million acres. The fourth State, Colorado, grows about 250,000 acres annually, and the other States, in descending order, are New Mexico and California with an average of about 140,000 acres, and Arizona, Nebraska, Missouri, and Iowa with from 30,000 down to less than 10,000 acres annually.

The distribution of acreage of grain sorghums in eight of these States in 1919 is shown in Figure 46. The distribution of corn acreage in the same States, except Missouri, is shown in Figure 47.

TABLE 4.—*Annual and average acreage, acre yield, production, bushel value, and total value of the sorghum grain grown in Arizona, California, Colorado, Iowa, Kansas, Missouri, Nebraska, New Mexico, Oklahoma, and Texas in 1909 and in the eight years from 1915 to 1922, inclusive.*

Year.	Acreage.	Acre yield.	Production.	Value.	
				Per bushel.	Total.
		<i>Bushels.</i>	<i>Bushels.</i>	<i>Cents.</i>	
1909.....	1, 631, 000	10. 7	17, 526, 000	60. 2	\$10, 766, 000
1915.....	4, 153, 000	27. 6	114, 460, 000	44. 7	51, 157, 000
1916.....	3, 944, 000	13. 7	53, 858, 000	105. 9	57, 027, 000
1917.....	5, 153, 000	11. 9	61, 409, 000	161. 9	99, 433, 000
1918.....	6, 036, 000	12. 1	73, 241, 000	150. 0	109, 881, 000
1919.....	5, 060, 000	25. 8	130, 734, 000	127. 4	166, 510, 000
1920.....	5, 120, 000	26. 8	137, 408, 000	92. 9	127, 629, 000
1921.....	4, 635, 000	24. 6	113, 990, 000	39. 1	44, 575, 000
1922.....	5, 051, 000	17. 9	90, 381, 000	87. 6	79, 389, 000
8-year average, 1915-1922.....	4, 894, 000	20. 1	96, 935, 000	101. 2	91, 950, 000
6-year average, 1915-1920.....	4, 911, 000	19. 7	95, 185, 000	113. 8	101, 940, 000
2-year average, 1921-1922.....	4, 843, 000	21. 3	102, 186, 000	63. 4	61, 982, 000

### Factors Affecting Production.

The chief factors affecting the production of the grain sorghums are climatic, namely, moisture and temperature. These crops can be grown successfully under a lower effective rainfall than is required by corn, but require higher temperatures for both germination and satisfactory growth. These facts serve to show why the grain sorghums are dominant crops in the area they occupy (Fig. 46).

To the east of this area humidity increases and corn holds its own against the grain sorghums, even if the yield of corn is somewhat below that which the grain sorghums will produce under those conditions. This is true partly because corn is a more efficient feeding grain and partly because it is more easily harvested and more safely stored and transported. Corn is easily husked either from the row or shock.

Corn can be stored in bins immediately on gathering without particular danger of injury except from rats and mice. Heads of the grain sorghums, on the other hand, must be

dried or cured in the open before they can be binned in quantity, and even then the bins should be well ventilated. Shelled corn also can be stored safely unless the moisture content is too high, whereas shelled sorghum grain, unless clean from dirt and cracked kernels, must be carefully watched to prevent heating.

To the north and west of the present producing area are large areas of dry land where deficient moisture prevents profitable production of corn, but where increasing elevation and increasing latitude, or both, shorten the growing season so that grain sorghums will not mature satisfactorily. They are much more sensitive than corn to low temperatures in soil and air during germination and early growth.

*Fungous diseases.*—The only important diseases of grain sorghums are the smuts, of which there are three different kinds. The most widely distributed and most destructive is the covered kernel smut. The loose kernel smut is sporadic in occurrence and causes little damage. These two smuts can be controlled through seed treatment and the use of resistant varieties. Head smut is less widely distributed but may cause heavy local damage. This smut can not be controlled by seed treatment. The varieties of milo do not become smutted under field conditions.

*Insects.*—The principal insect enemy of the grain sorghums in the Southwest undoubtedly is the sorghum midge. This pest affects the production of the grain only, but doubtless is the limiting factor in the production of sorghum seed in parts of Texas and other important sorghum States. Two species of stalk borers are of very considerable importance to the production of the sorghums throughout the Gulf and Southwestern States. One of these causes injury up to altitudes in excess of 4,000 feet.

### Marketing Grain Sorghums.

The grain sorghums are grown primarily for feeding grains and fodders for farm use. Estimates show that only about 25 per cent of the crop moves off the farms where grown. Not all of this reaches the terminal markets, as much of that sold off the farm is consumed locally. The main terminal markets for the grain sorghums are Kansas

City to the north, St. Louis and Memphis to the east, Fort Worth and Galveston to the south, and Los Angeles to the west of the main producing area. The Kansas City market is the largest handler of the grain sorghums.

The chief commercial uses of sorghum grain are similar to those of corn, and it must compete with that grain. This means that sorghum grain moving north and east into corn-producing territory must be either cheaper or better than corn for the purpose desired. If cheaper, it must be sufficiently cheaper to pay for the longer haul and to overcome the handicap of lower feeding value, which is about 80 to 90 per cent of that of corn. Occasionally this condition occurs. Under these conditions also some sorghum grain may be used in the manufacture of industrial alcohol. For poultry feeds the grain of various sorghums is more suitable than corn in size. A considerable portion of the commercial movement both east and west is for this purpose. In the far West, however, little corn is produced, and some of the western commercial movement of grain sorghums doubtless is for use in stock feeding.

*Classes.*—Under the United States grain standards act classes and grades have been established for grain sorghums. The nine commercial classes are as follows: (1) Kafir, (2) milo, (3) durra, (4) feterita, (5) darso, (6) freed sorgo, (7) brown kaoliang, (8) schrock kafir, and (9) shallu. Any class containing more than 10 per cent of another is designated "mixed grain sorghum." Only the first four of the nine classes are important, as production of the other five is very limited. Kafir and milo comprise more than 90 per cent of the total sorghum grain graded at the principal markets. Three classes, kafir, milo, and durra, are divided into two subclasses on the basis of color of kernels. These grades are not enforced under the grain standards act, but they have been adopted by all important grain-sorghum markets and used during the last crop year.

*Quality.*—Because of the very dry conditions under which this grain is produced, the seeds crack easily in thrashing. Unless this cracked material is screened or fanned out, there is danger that the grain will heat when binned on the farm or in elevators and mills. The small size of the

kernels allows them to pack tightly together and when they are mixed with the still finer cracked material they form an almost air-tight mass which heats readily. More than ordinary care must be taken, therefore, to ventilate storage bins or to move the grain at intervals.

*Grade.*—Grade depends upon quality at time of inspection. Each class or subclass is divided into four grades, Nos. 1, 2, 3, and 4, with a “sample grade” for grain failing to meet the specifications of any of the numbered grades. Sufficient data are not available to show the percentage of sorghum grain in interstate movement which falls into each of these grades.

### Grain Sorghums for Food and Feeding.

The grain sorghums are a comparatively new crop in the United States. They resemble corn in composition and have similar uses in cookery. They also have a characteristic flavor. Griddle cakes and hot breads resembling corn bread are well known in home cooking, and a breakfast food is manufactured. The kernels of some of them can be popped, the product resembling pop corn in miniature.

Grain sorghums are used mostly as a feed for farm animals on the farms where grown. They also are regarded as an essential ingredient of scratch feeds for poultry. A survey made some years ago showed that about one-fourth of

### KAFIR, MILO, AND CORN FOR FATTENING HOGS.

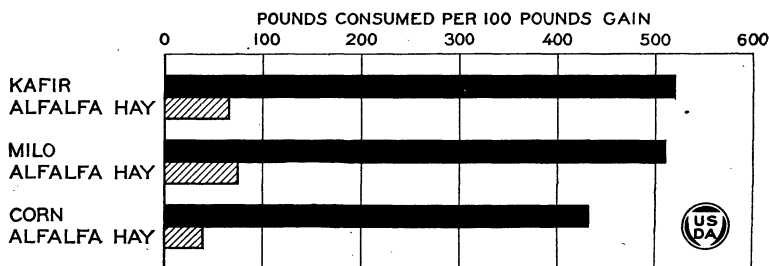


FIG. 48.—This graph represents the results of experiments in feeding kafir, milo, and corn conducted by the Kansas Agricultural Experimental Station, as published in Bulletin 198. Ten shotes in each lot, averaging 124 pounds each, were fed for 80 days. It required about 20 per cent more kafir or milo than corn to produce 100 pounds of gain. Both the corn and the grain sorghums were ground. Other experiments at the same station showed that a feed rich in protein should be fed with the grain sorghums.



the manufactured poultry foods consisted of sorghum grains. The attention of manufacturers of alcohol and starch also is being turned to these grains. Feterita and milo, with large seeds averaging 65 per cent of starch, seem to be especially suitable as raw material for the manufacture of high-grade starch by the commercial process.

The grain sorghums are becoming very important for live-stock feeding in the Southwest, where the climate is too dry for corn. They have a feeding value about 80 to 90 per cent of that of corn (Fig. 48). They are suitable for feeding all kinds of live stock. For sheep they should be ground, but otherwise they should be fed about the same as corn. They may not produce quite as high a finish as corn. They need to be supplemented by a protein concentrate or legume roughage just as corn does. They are not shipped extensively, except as poultry feed. Thus far no considerable quantity of by-products results from the commercial use of grain sorghums.

### Seed Flax.

#### Importance of the Crop.

Among the grain crops of the United States seed flax ranks seventh in acreage and eighth in value, being exceeded by corn, wheat, oats, barley, rye, and grain sorghums in acreage and by these crops and rice in value. (Fig. 1.) The area harvested in 1919 was 1,260,000 acres, while that of 1922 was estimated at 1,308,000 acres, with a production of 12,238,000 bushels.

The seed-flax crop of the United States is grown in the same region as the hard red spring wheats. The four States of North Dakota, Minnesota, South Dakota, and Montana produce 95 per cent of the total crop. In these States flax is important as a cash crop, and also as one that can be sown late in the spring on newly broken sod or on land previously too wet to work.

#### World Production and Trade.

At the beginning of this century Argentina and Canada were just becoming important flax producers. The United States was then approaching its maximum production, which

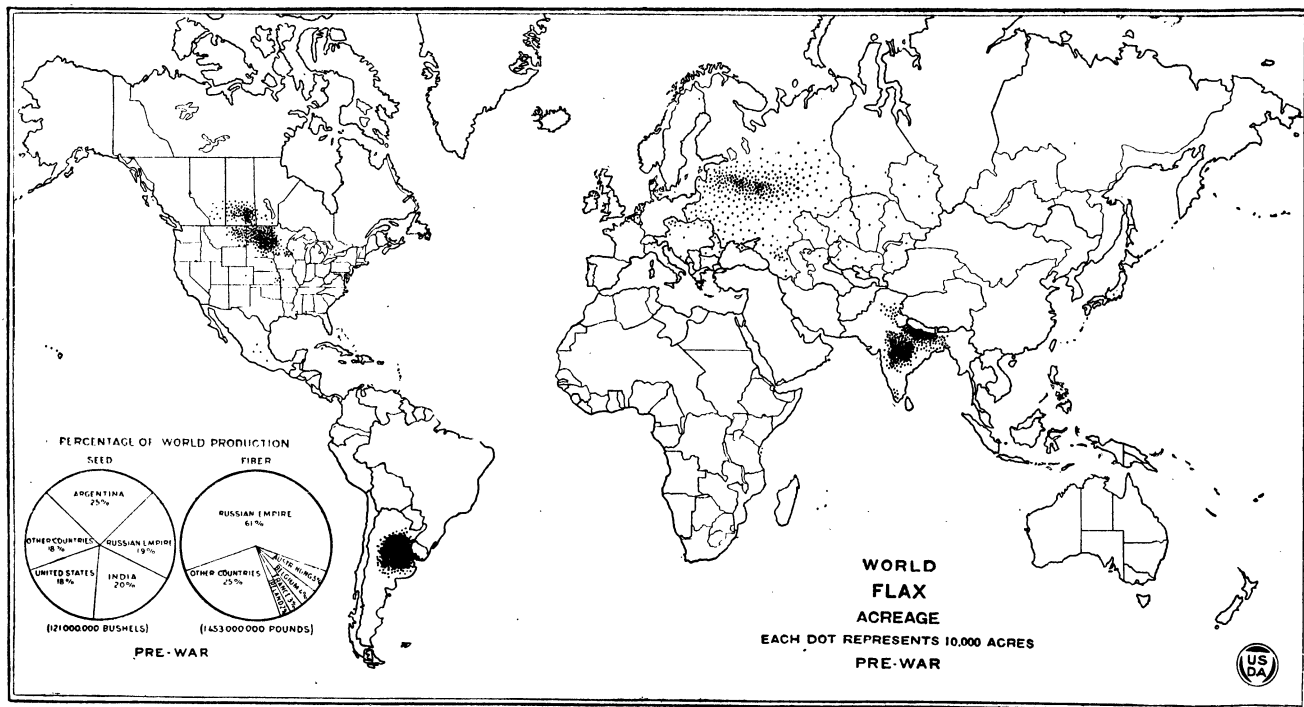


FIG. 49.—Pre-war flax acreage of the world and chief producing countries. Four centers of flax culture are to be noted—central North America, Argentina, Russia, and India. In pre-war production of seed flax the five leading countries in order were Argentina, India, the Russian Empire, the United States, and Canada. The maximum world production of flaxseed was reached in 1912 and 1913, according to available statistics, when over 130 million bushels were produced each year.

occurred in 1902, since which time a steady decline in production has taken place. In Argentina and Canada, our principal competitors, production continued to increase rapidly until 1912 or 1913. Since those years production in Canada has diminished while that in Argentina has remained about stationary. In recent years production of flaxseed in the United States has diminished to about 10,000,000 bushels annually, while consumption continues at 25,000,000 bushels or more. The difference is made up by imports of flaxseed chiefly from Argentina and Canada.

Previous to the World War the principal countries producing seed flax were Argentina, India, Russia, the United States, and Canada, in the order named. The average world production for the five-year period, from 1909 to 1913, inclusive, was estimated at about 110,000,000 bushels annually. In the last three years of this period production had increased until the average production was 121,000,000 bushels, as shown in Figure 49. The bulk of the crop of Argentina, India, and Canada was shipped to Europe or to the United States, where the linseed oil was manufactured and consumed. The Russian crop was used wholly in Europe. Since the war Russia has not produced flax for export. Argentina is by far the largest producer, and, as her domestic requirements are small, she also is the largest exporter.

Western Europe and the United States, with intensive paint, varnish, and linoleum industries, are the chief importers of flaxseed. There is also a large demand from the dairy industries in these countries for linseed cake and meal as a feeding concentrate.

#### **Trend of Acreage, Production, and Price in the United States.**

Previous to the Civil War the production of flaxseed was scarcely more than a half million bushels annually. With the settlement of the western prairies acreage and production increased rapidly. Both reached their maximum in 1902 (Fig. 50) when over 29 million bushels were raised on 3,740,000 acres. Since 1902 acreage and production have gradually declined, as has also acre yield since 1905.

*Exports and imports.*—In Figure 51 are shown production and consumption and net exports and imports of the

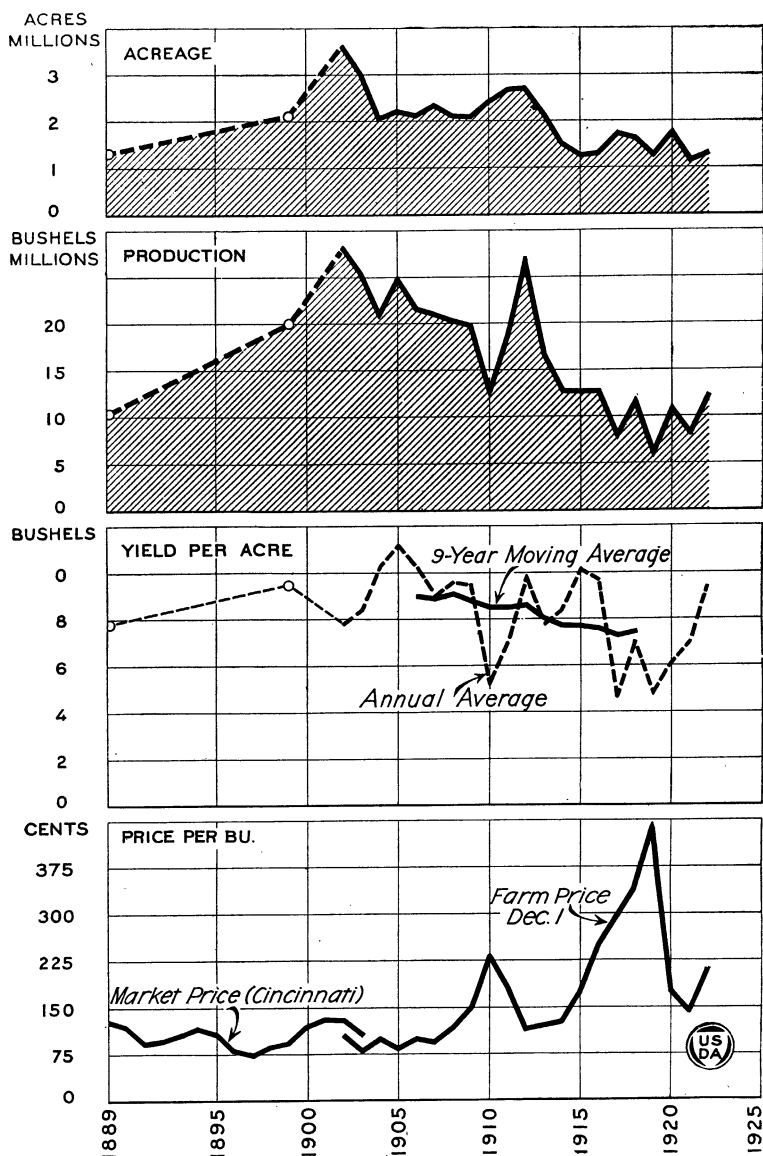
**FLAX: ACREAGE, PRODUCTION, ACRE YIELD, AND FARM PRICE, UNITED STATES, 1889, 1899, AND 1902-1922.**

FIG. 50.—Annual acreage, production, and yield per acre in 1889 and 1899 are shown. The general trends of annual acreage and production, and annual and 9-year moving average acre yield have been downward since 1902. The trend of annual average farm price per bushel on December 1 since 1907 has been upward and reached a very high figure in 1919.

**FLAXSEED PRODUCTION, NET IMPORTS, NET EXPORTS,  
AND TOTAL CONSUMPTION IN THE UNITED STATES,  
1899-1921.**

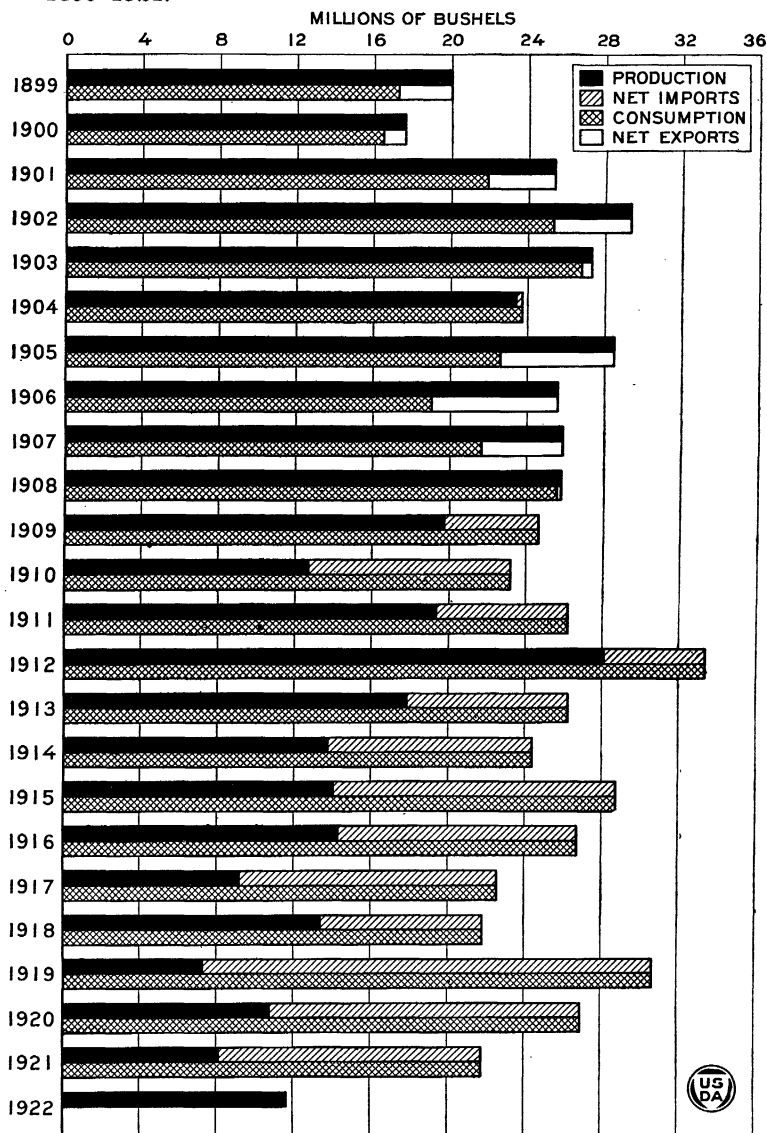


FIG. 51.—The production of flaxseed in the United States exceeded consumption from 1899 to 1908, except in 1904, and the surplus was exported to Europe. Since 1909 production has decreased notably, while consumption (including seed and carryover) has remained about stationary, and the difference is made up by imports which in recent years have come chiefly from Argentina and Canada. The large production of 1912 was due to an increased acreage, with a high average yield, 9.8 bushels. The imports of 1912 came almost entirely from Canada, where a crop of over 26 million bushels was produced that year.

United States from 1899 to 1921, inclusive, with production for 1922. Until 1908 we produced, on the average, more than we consumed and therefore were able to export a surplus in nearly every year. Beginning with 1909, however, our production began to decline, while our requirements continued to increase with population. Net imports consequently have increased. The reduction in consumption in 1917 and 1918 was due to war restrictions, and that in 1920 and 1921 to business depression. It is fairly certain that the figures for 1922, when available, will show an increase of consumption.

As the United States changed in position from an exporter to an importer of flaxseed the farm price of flax increased materially (see Fig. 50). In 1907, when a surplus of over 4 million bushels was exported, the farm price of flaxseed on December 1 averaged 96 cents per bushel. In 1908, when production and consumption were practically equal, the farm price of flaxseed was \$1.18 per bushel. In 1909, when 4,957,000 bushels were imported, the farm price rose to \$1.53 per bushel. The December 1 farm value of the 25,851,000 bushels of the 1907 crop was \$24,713,000, while the farm value of the 19,513,000 bushels of the smaller crop in 1909 was \$29,795,000.

#### Historical Development of Flax Production.

Flax, cultivated for its fiber, was one of the first plants introduced from the Old World. Records are found of its cultivation soon after the landing of the Pilgrims in Massachusetts in 1620, and it continued to be grown to some extent as a fiber crop for home use as late as 1840. It was about the beginning of the nineteenth century when the manufacture of linseed oil was begun in this country.

Seed flax has held the unique position of a "pioneer crop" in the agriculture of the United States, as it has been grown largely as the first crop on breaking or newly turned virgin sod. The area of flax production, therefore, has moved westward with the settlement of new lands until now it has reached about the western limit of its migration. Seed flax is raised as a cash crop, practically none of the crop

except the straw being consumed directly on the farms where grown.

The census of 1850 showed Ohio and Kentucky to be the chief flaxseed-producing States in 1849. By 1859 flax was well established in Indiana, and in 1869 in Illinois and Wisconsin. Ten years later, in 1879 (Fig. 52), Iowa was producing a considerable quantity of flaxseed, and by 1889 (Fig. 53) Minnesota, Iowa, and South Dakota were the principal producing States. By 1899 (Fig. 54) North Dakota had taken the lead in the production of flaxseed, and, with Minnesota and South Dakota, it still continues to produce the bulk of our crop (Figs. 55 and 56).

Formerly flax was considered to be hard on the soil because it did not produce well if grown continuously on the same field. About 1900 a flax disease called flax wilt was discovered. It was found also that it became more and more destructive if flax was grown for several years on the same piece of land. This probably accounts for the idea that flax was hard on the land and for its steady westward migration to new soils during the last 75 years.

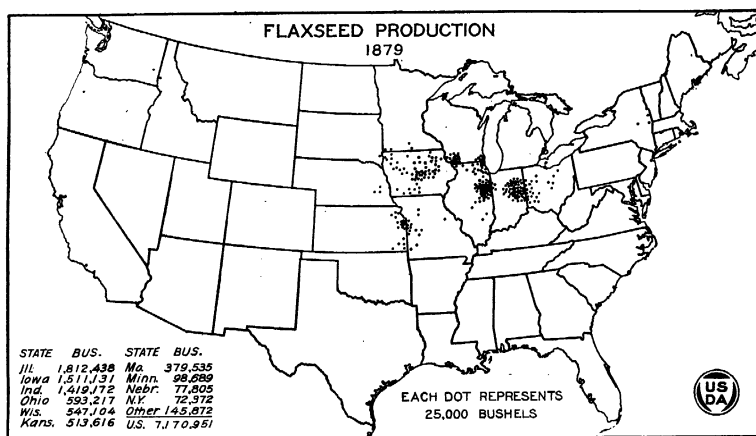


FIG. 52.—In 1879 the centers of flaxseed production were located in the Mid-Western States. Four centers are seen, namely, in Indiana, Illinois, Iowa, and Missouri-Kansas. The latter was a new development, producing 893 thousand bushels in that year. It increased during the next 20 years and became known commercially as the "southwestern crop." Flax was just appearing in Minnesota and the Dakotas, which 20 years later were to become the centers of production.

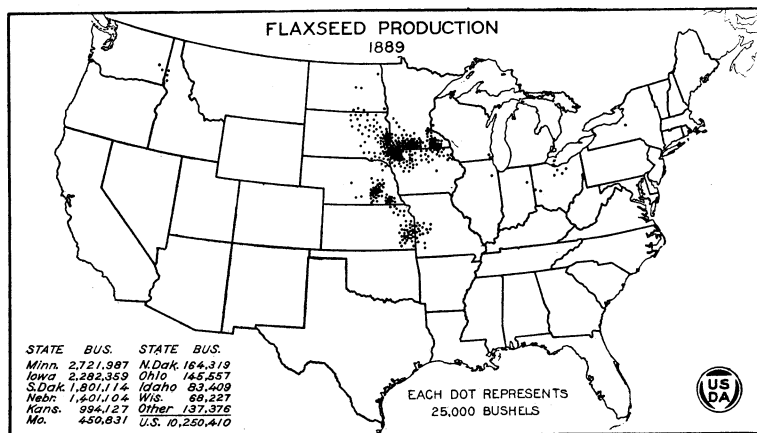


FIG. 53.—By 1889 a remarkable shift has taken place. Production has almost disappeared from Indiana and Illinois and other States east of the Mississippi River. The production in Iowa has moved northwestward and become part of a new and very important center covering the adjacent portions of Minnesota, Iowa, and South Dakota. A new center has appeared in southeastern Nebraska, while the Missouri-Kansas production has increased.

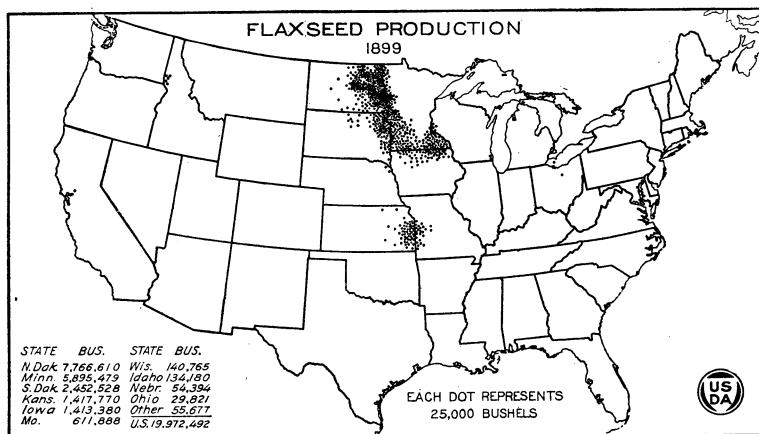


FIG. 54.—By 1899 the center of production has shifted again to the northwestward. North Dakota has become the leading producer, its producing area being continuous with that of Minnesota, South Dakota, and northern Iowa. Production in Nebraska has disappeared, while that of the Missouri-Kansas area has increased, especially in Kansas. East of the Mississippi production has almost disappeared.



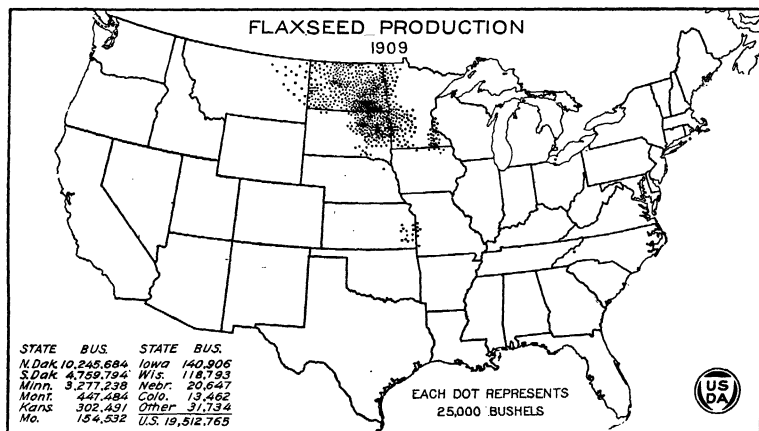


FIG. 55.—Only one important producing center remains in 1909, and it has moved steadily northwestward during the decade just passed. North Dakota remains the leading producing State, but production now covers the entire State, instead of being concentrated in the eastern portion, and the area now extends into northeastern Montana. South Dakota and Minnesota produce relatively less, while production in Iowa has nearly disappeared. The Missouri-Kansas center has been greatly reduced. North Dakota produces more than half of the total quantity.

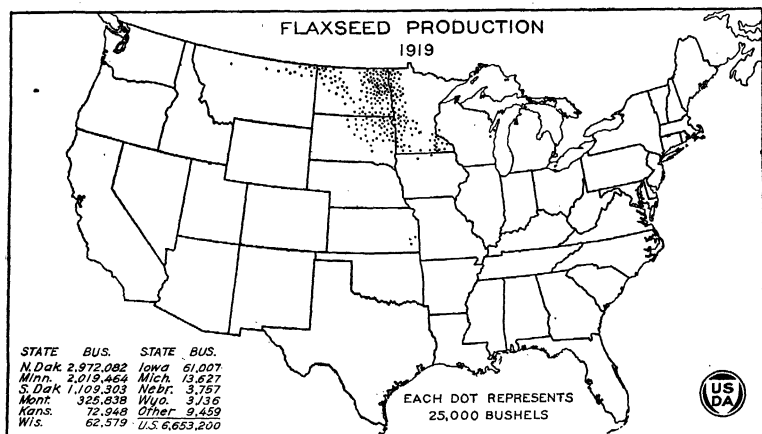


FIG. 56.—The crop in 1919 has about the same distribution as in 1909 but, owing to very unfavorable climatic conditions, production was only one-third that of 1909, and also was the smallest of recent years. The western movement has reached the foothills of the Rocky Mountains, and probably has reached the western limit to its migration. Any future increase in production probably must occur in the States where the crop is now grown, or through a development of the flax industry in States farther east, where it once was grown so abundantly.

### Natural Factors Influencing Production.

Of the natural factors influencing seed-flax production from year to year, climate, especially rainfall, competition from weeds, and fungous diseases, especially flax wilt, are the most important.

*Soil and climate.*—As flax roots ordinarily do not feed deep in the soil, flax does best on loam or clay soils which are fertile and retentive of moisture. Abundant moisture during the growing period, with drier conditions during the ripening and harvest period, is very favorable for flax.

Flax is particularly well adapted to seeding on freshly turned or backset sod where, comparatively, it does better than most other farm crops. In a rotation, therefore, it is likely to do well following a sod-forming crop such as clover and timothy, or on corn ground following such a crop. Plowed pasture lands are excellent for flax. Flax often is sown late on land that is too wet to seed early in the season, and it is well adapted for this purpose, as it matures in a comparatively short season. As flax does not produce a dense shade it can be sown as a nurse crop with alfalfa, clover, or grass.

*Weeds.*—Flax does not compete well with weeds, and therefore it is generally grown on new land or after a grass crop, or following a cultivated crop where weeds have been eliminated.

*Diseases.*—The principal diseases of seed flax are wilt, heat canker, and rust. Wilt is a fungous disease which causes marked losses only where flax is grown continuously on the same land or on old, wilt-infested land, where it may cause a total loss of the crop. Fortunately, a number of fairly satisfactory wilt-resistant flax varieties are available.

Heat canker is caused by excessively high temperatures at the soil surface when the plants are very young. It occasionally causes marked losses, especially in western North Dakota and eastern Montana. The stems are girdled and the affected plants break over. Some of these die, but others continue to grow poorly. The most feasible control measure appears to be early seeding. This enables the plants to pass the susceptible stage before the hot weather of late June and early July.

Flax rust is important chiefly in limited sections of the Red River Valley of North Dakota and Minnesota. It lives over winter only on the old flax stubble and straw. Proper crop rotation is the only available control measure at present.

*Insects.*—Grasshoppers frequently do great injury to flax in the northern Great Plains area. These insects eat off the slender branches of the ripe panicles, which allows the seed bolls to drop to the ground. Grasshoppers are controlled by poisoning with bait prepared with wheat bran and scattered through the fields.

#### Markets and Marketing.

Flaxseed grown in the United States is marketed at local elevators in the same way as wheat or other small grains. In many localities of small production, however, a comparatively small volume of seed is marketed; and because the price often fluctuates widely, flaxseed usually is bought on a wider margin than is wheat, and the grower often does not receive the full value of his crop. This condition could be improved if several growers of flaxseed in such localities would combine their deliveries and thus market a carload or more at one time.

*Classes.*—At the present time there are three recognized commercial classes of flaxseed: (1) Northwestern-grown seed, (2) southwestern-grown seed, and (3) foreign seed. Northwestern-grown seed is that portion of the domestic crop grown almost entirely in five States, namely, North Dakota, South Dakota, Minnesota, Montana, and a small portion of northern Iowa. It comprises nearly 95 per cent of our domestic production. This class includes also the seed imported from Canada. This is produced just across the line from North Dakota and Montana and is comparable in quality to our production. The southwestern seed constitutes only about 5 per cent of our crop and is grown in Missouri, Kansas, Nebraska, and eastern Wyoming. It is inferior to the northwestern-grown seed.

Foreign seed is that imported from South America, Manchuria, and India. The greater proportion of the seed imported into the United States comes from Argentina, a

smaller quantity from Canada, already discussed under the northwestern-grown class, and sometimes a still smaller quantity from Manchuria and Siberia. Only occasionally does any seed arrive from India.

**Markets.**—The principal markets for domestic flaxseed are, in order of their importance, Minneapolis, Duluth, Milwaukee, and Chicago for northwestern-grown seed, and Fredonia, Kans., and Des Moines, Iowa, for the southwestern-grown seed. Much of the imported seed comes through the port of New York. It is not all crushed there, however, a considerable portion being shipped to Buffalo for crushing.

**Crushing centers.**—The linseed-crushing industry is widely distributed throughout the United States, though there are two principal centers of manufacture. The larger part of our domestic seed is consumed in linseed mills in Minneapolis, St. Paul, Chicago, Superior, and Milwaukee, though some seed is shipped to Toledo and Buffalo by way of the Great Lakes. About half of our total linseed-oil manu-

**ANNUAL VARIATION IN QUALITY OF FLAXSEED, MINNESOTA MARKETS, IN CROP-MOVEMENT YEARS ENDING AUGUST 31, 1919 TO 1922, INCLUSIVE.**

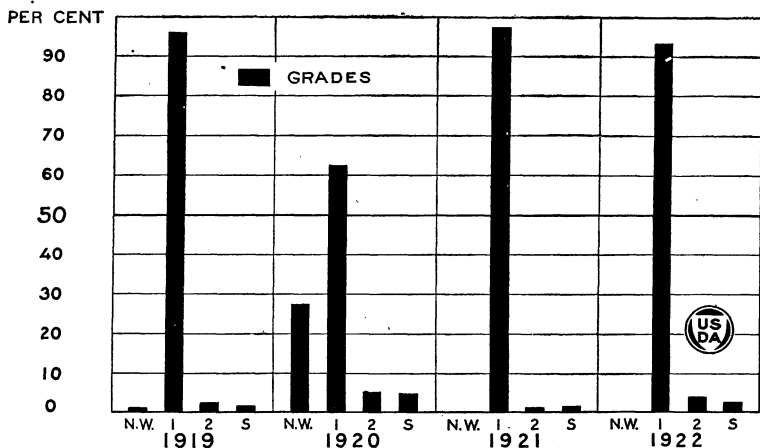


FIG. 57.—Percentage of annual flax marketings in Minnesota by grades. Nearly all the flax marketed in Minnesota, including that sold on the two principal markets of Minneapolis and Duluth, which receive the bulk of the crops from North Dakota, South Dakota, and Montana, is No. 1. The crop of 1919 (marketed in 1920) showed wider variation in quality than usual, about 28 per cent being graded as Northwestern, the highest grade.

factory is located in New York City and Buffalo. These mills depend quite largely on imported seed for their raw material. The western mills have the advantage of being close to our domestic supply of flaxseed, while the eastern mills have the advantage of cheap ocean freight rates on flaxseed from Argentina and also on linseed cake, which is exported in large quantities to Europe.

*Grades.*—At the present time six States and four boards of trade or chambers of commerce have special sets of grading rules for grading flaxseed. The grades vary in number from three to four. Apparently only one or two grades are of importance (Fig. 57). About 75 per cent of our domestic crop is marketed at Minneapolis and the remainder at Duluth, Milwaukee, and Chicago. Due to this fact, the rules of the Minnesota State Inspection Department are the ones most largely in use. Chicago and New York use the Minnesota State Inspection Department classifications. All foreign seed imported into this country is graded by the Linseed Association of New York, an organization of buyers and sellers, who sample and grade all imported oil-bearing seeds.

*Quality as shown by grade.*—The quality and consequent grade of flaxseed are dependent on the weather conditions that prevail during the growing season and harvest and the condition under which flax is stored from the time of harvest until it is marketed. The total receipts of each grade at all inspection points within the State of Minnesota for the four crop-movement years—September 1, 1918, to August 31, 1922, inclusive—are shown in Figure 57. These receipts cover the crops of 1918 to 1921, inclusive. The figures show that nearly all the flaxseed goes into grade No. 1.

#### Uses of Flaxseed.

The principal products of flaxseed are linseed oil, for paints and manufacturing purposes, and linseed meal, used for feeding stock.

In the manufacture of linseed oil the seed is ground, heated, and pressed to extract the oil. The residue remaining after pressing is known as linseed cake, or, when ground, as linseed meal. The oil is used chiefly in paints and varnishes and in the manufacture of linoleum, oilcloth, printer's ink, patent leather, and a few other products. The seed

contains from 30 to 40 per cent of its weight in oil and yields about  $2\frac{1}{2}$  gallons ( $7\frac{1}{2}$  pounds per gallon) of oil to the bushel (56 pounds) of flaxseed.

The whole seed is very rarely fed to live stock. As flax has a much lower proportion of hulls than cottonseed, it produces a much more uniform product than cottonseed meal, especially in protein content. While it usually contains less digestible protein than cottonseed meal, the fact that it has laxative properties compensates for the greater percentage of digestible protein in cottonseed meal. The latter, in fact, is costive. Linseed meal has no toxic properties such as cottonseed meal has. In feeding it care should be taken to avoid excessive laxativeness. It is especially valuable as a source of protein for all young growing stock and to breeding animals previous to parturition. As a supplement to corn it compares favorably with tankage and milk for fattening hogs.

Flaxseed is used little, if at all, as human food, except that it forms a part of certain food products, homemade or commercial, intended for the relief of constipation. In Europe linseed oil is used for food purposes to a very considerable extent in certain localities, as in the River Spree district of Germany, for instance.

### Buckwheat.

Buckwheat does not belong to the grass family and therefore is not truly a cereal. It is grown, however, for the making of flour for human consumption, and hence is a cereal substitute.

#### Importance of the Crop.

Buckwheat is an important crop in certain limited sections of the United States. More than 60 per cent of the crop is produced in the two States, Pennsylvania and New York, while nearly 20 per cent is produced in West Virginia, Virginia, Michigan, and Wisconsin combined. In portions of these States, especially in those localities leading in production, a considerable portion of the cultivated land is devoted to the crop.

Buckwheat, however, is a comparatively unimportant crop in the United States. For every bushel of buckwheat

produced in 1922 there were produced 192 bushels of corn, 57 bushels of wheat, 81 bushels of oats, 12 bushels of barley, 6 bushels of rye, and nearly 3 bushels of rice. Furthermore, buckwheat is never likely to attain greater relative importance as a crop in this country. But it has a place of importance in the agriculture of the areas where it is now grown, and there is a definite and steady demand for the grain and its products.

#### World Production of Buckwheat.

Postwar statistics on buckwheat production in all the producing countries of the world are not available. In the period from 1909 to 1913, however, the United States, with an annual average of 17,528,000 bushels, was surpassed only by Russia (pre-war European and Asiatic) with over 55,000,000 bushels, and by France with over 21,000,000 bushels. Canada produced about one-half and Japan about one-third as much as the United States.

#### Trend of Production in the United States.

Buckwheat acreages in the United States from 1866 to 1869 apparently were very high. A sharp drop in acreage occurred in 1870, and this reduction persisted through 1874. From 1876 to the present time the acreage in the United States has been nearly stationary, as is shown in Figure 58. The smallest acreage in this period was in 1900, when only 638,000 acres were sown to this crop. The largest acreage in this period was in 1919, when 1,084,000 acres were sown.

Production of buckwheat, depending as it does on both acreage and acre yield, has varied more from year to year than has acreage. Acre yields, somewhat larger than usual in several of the years since 1909, and larger acreages in a few of those years, have resulted in increased production since that date.

The acre yield of buckwheat has fluctuated considerably from year to year. The lowest recorded acre yield was 8.9 bushels, in 1883. The highest was in 1912, when it reached 22.9 bushels.

Farm prices per bushel of buckwheat on December 1 of each year fluctuated between 40 and 80 cents in most of the period from 1866 to 1915. The minimum was 39.2 cents in

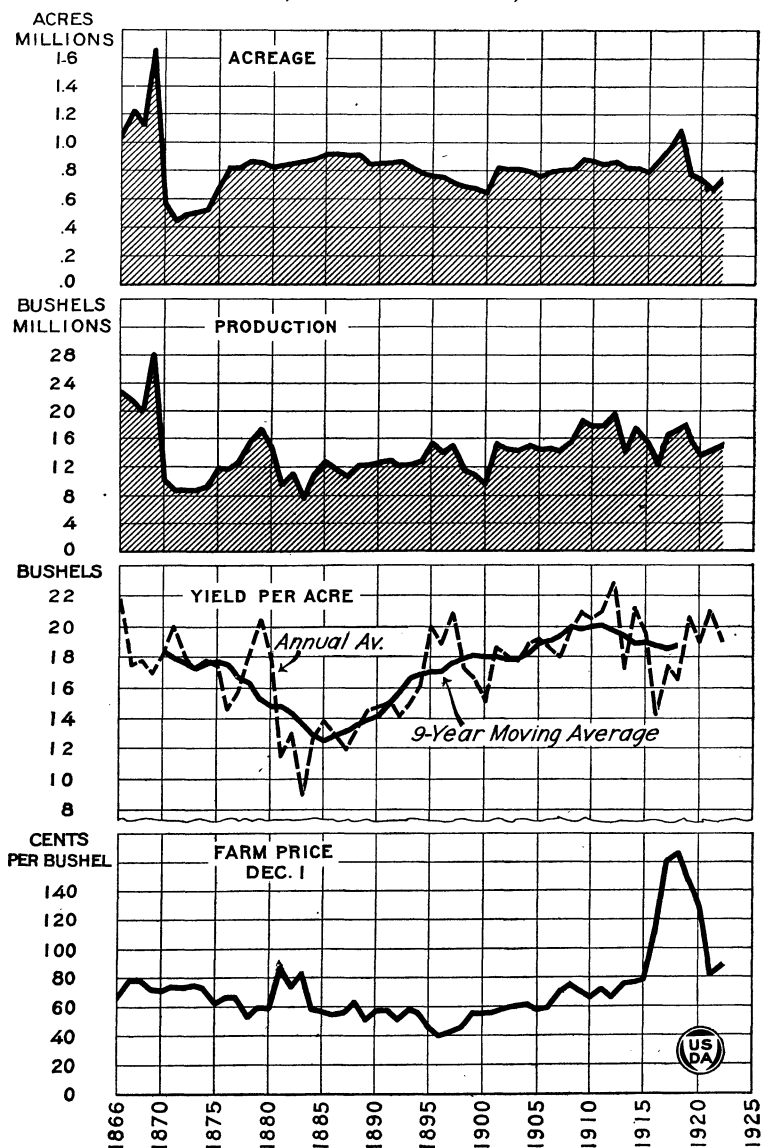
**BUCKWHEAT: ACREAGE, PRODUCTION, ACRE YIELD, AND FARM PRICE, UNITED STATES, 1866-1922.**

FIG. 58.—Since about 1876, fluctuations in buckwheat acreage have been slight. Production has fluctuated somewhat more widely, owing to seasonal conditions, but the general trend has been upward since 1883. Average acre yield increased rather steadily from 1885 until 1912. Price trend was downward until 1896, and then upward steadily to 1915, then rapidly upward to 1918, after which it fell rapidly.



1896, and the maximum was 86.5 cents in 1881. In 1916 the bushel price rose to about \$1.13 and in the next year to \$1.60. The highest price recorded during this war period was \$1.67, in 1918, after which time the prices rapidly fell to the comparatively low price of 81.2 cents on December 1, 1921. In 1922 the price on this date was 88.5 cents.

#### Historical Development of Production in the United States.

Buckwheat was brought from Europe to the United States by the early settlers. The Dutch colonists who had settled along the Hudson River, according to early records of the colony, sent samples of buckwheat back to Holland, along with grain of other crops, after the harvest of 1625. Buckwheat does not appear to have been an important crop in the early colonial days. Corn, wheat, and rye were largely depended upon for food, while buckwheat is not often mentioned. The production of this crop, however, increased with the growth of the country, for 7,291,743 bushels of buckwheat are reported in the first agricultural census in 1840. The historical development of buckwheat production, as shown by census reports each 20 years following 1839, is given in discussions in connection with the production maps (Figs. 59-61).

Buckwheat growing always has been confined to the northeastern quarter of the United States, and the center of production always has been in New York, Pennsylvania, and northern New Jersey, with some overlapping into eastern Ohio. The economic significance of the crop is that it can be grown on soil not satisfactory for wheat and that buckwheat carries the production of a bread grain a little farther into otherwise unproductive areas. It also is a crop that has been used on newly cleared land and land just being brought under cultivation, and is widely used as a honey plant.

#### Factors Influencing Buckwheat Production.

Buckwheat in general is the best grain crop for poor, thin land. Its natural and favorite environment is "back in the hills." On land where wheat or even rye can not be grown with profit buckwheat often is able to produce a profitable yield. The climatic conditions, however, must be favorable.

On acid soils, which are quite common in the Northeastern States, buckwheat does well. It does not require large supplies of lime in the soil, although lime is taken up largely by the plant.

Buckwheat is a suitable crop for growing on new land. Land just cleared of timber or drained marshland containing much decaying vegetable matter will produce good yields of this grain.

Buckwheat serves to make even very hard land mellow and friable. Consequently it is a good crop to use in preparation for such crops as potatoes.

Low-grade fertilizers may be used to advantage in the growing of buckwheat, as it can make use of relatively insoluble materials to better advantage than the other cereals.

As it has a short growing period, buckwheat can be grown on land where fall-sown crops have winterkilled or spring-sown crops, such as corn, have failed to make a stand. It

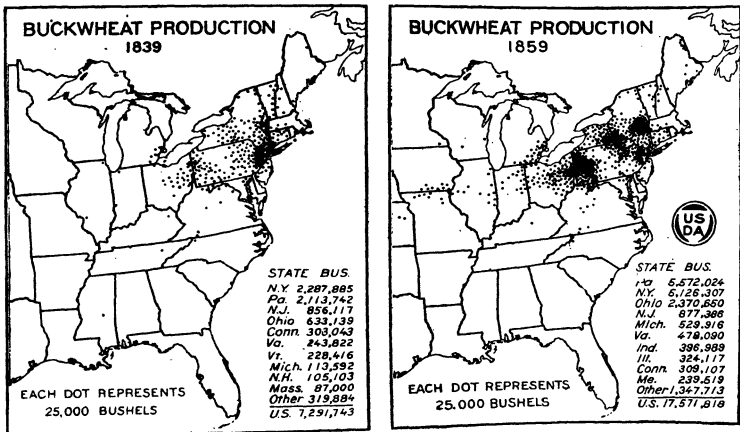


FIG. 59.—In 1839 the production of buckwheat centered in southeastern New York, eastern Pennsylvania, and northwestern New Jersey. About 60 per cent of the total crop of the United States was produced by New York and Pennsylvania, and this is not far from the proportion that they produce at the present time. New Jersey was third in production, followed by Ohio and Connecticut. Twenty years later, in 1859, three distinct areas of large production had developed, one in east-central New York, one in south-central New York and north-central Pennsylvania, and the third in western Pennsylvania and eastern Ohio. The former most important center in New York, Pennsylvania, and New Jersey had decreased greatly in importance. The production of buckwheat had extended westward in Ohio and developed somewhat in Michigan, Indiana, Illinois, Iowa, and Missouri.

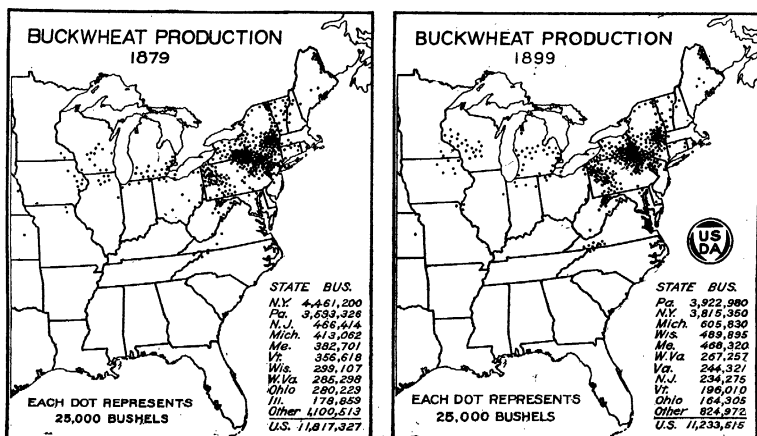


FIG. 60.—The most important change shown in 1879 was the decrease that had taken place in the western Pennsylvania and eastern Ohio area. Ohio had dropped from about  $2\frac{1}{2}$  million bushels to about 280 thousand bushels in production, or from third to ninth in State rank. The acreage in New Jersey was reduced to about one-half. The two centers in New York and Pennsylvania retained their importance. The States in the Corn Belt had reduced production, but there was some increase in Wisconsin. At the end of another 20 years, in 1899, not much change had taken place. The total production of buckwheat was somewhat less than in 1879. The area in east-central New York had decreased in production. The area in south-central New York and north-central Pennsylvania was the most important.

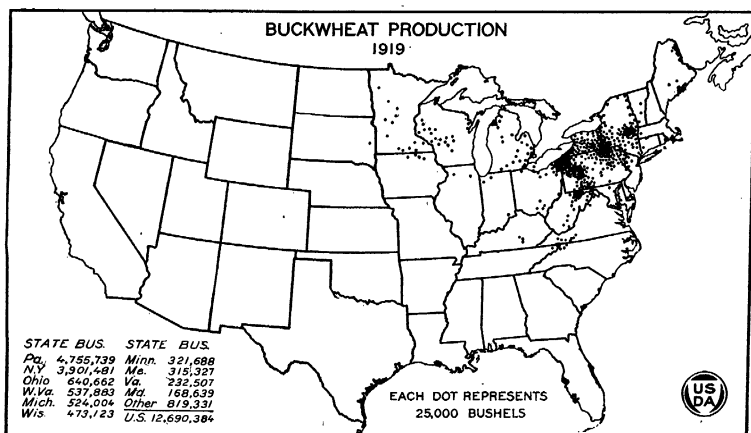


FIG. 61.—The buckwheat map for 1919 shows an increased production in northwestern Pennsylvania and southwestern New York and in northeastern Ohio. New Jersey has still further reduced production, while some increases have taken place in the mountainous sections of West Virginia and Maryland. The total production in this year was less than it had been 50 years before, due principally to decreased acreage.

also can be used where the land can not be worked until late, or where other crops have been drowned out by late spring floods.

Buckwheat can be used to enlarge farm activities. After other crops that must be sown early are all sown there often is time to prepare land and sow buckwheat. On account of the short growing season it may be sown later than any other grain crop. Where it is so used it often may be advisable to sow it even on rich land which otherwise could be used more profitably for other crops.

*Climatic requirements.*—Buckwheat in general is less critical as to soil conditions and more critical as to climatic conditions than the other grain crops. From north to south it becomes more and more a crop only for the higher elevations, for it requires cool and moist weather, especially at blooming time. It is very sensitive to cold, being quickly killed by freezing temperatures, but fills best when the weather is cool. On account of its short growing season and the small amount of heat required for the total development of the crop, it is grown far north and at high altitudes. Unfavorable weather conditions at blooming time may reduce the yield or even destroy the crop altogether.

*Fungous diseases and insects.*—Buckwheat has no fungous or insect enemies of importance.

#### Trade Movement of Buckwheat.

Very little of the buckwheat produced is consumed unmilled on the farms where grown. However, buckwheat does not enter largely into interstate or foreign commerce, as most of the crop is milled in or near the locality where it is grown. Our exports and imports are not large and usually about balance each other, although they vary considerably from year to year. Our exports usually have been less than a half million bushels annually in recent years.

#### Buckwheat Foods and Feeding.

Buckwheat is grown for use as a food. It has a distinctive flavor, and in composition resembles corn more than it does wheat. The present use of buckwheat flour is chiefly for making pancakes, but in earlier times it was commonly used

for buckwheat shortcake or shortbread, a dish still known in some parts of the country. Groats or grits are made from buckwheat, though known only in a limited way in the United States. Buckwheat farina also is manufactured. Buckwheat is well known in northern Europe and Asia as a food grain.

The by-products of buckwheat milling are hulls, so-called bran, and middlings. The hulls are hard and woody and have little food value. The middlings are nearly free from hulls and make a very acceptable feed. The so-called "buckwheat bran" is really a mixture of middlings and hulls. Buckwheat is used as an ingredient of poultry scratch feeds.

Buckwheat fills a very insignificant place in the feeding of farm live stock. It is not very desirable as a whole grain on account of the small size of the kernel, the thickness of the hulls, and their indigestibility. It lacks the palatability of corn and barley. Only the lower grades are used for live stock on farms in the Northeast where it is grown, as the best grades are sent to the mills. The by-products from the mills are fed principally to hogs and cattle. The value of the by-products depends largely upon the percentage of hulls. Middlings low in hull content are a valuable feed for dairy cattle, being high in protein, carbohydrates, and fat. Buckwheat should be ground or crushed for all classes of live stock.

### Costs of Production.

#### Oats, Barley, and Rye.

It has been said that the difference in cost of producing the various small grains on the ordinary farm is too small to have any influence on the farmer's choice of which grain to include in his rotation. Although this is not necessarily true, it undoubtedly is a fact that the farmer's decision is affected more by the variations in income and other differences between these crops than he is by the relative cost. Oats, barley, and rye all require the same machinery, and usually may be produced and harvested by the same methods. Under these conditions the costs are bound to be much the

same, of course, excepting for difference in seed cost and in those factors that are affected by variations in yield (Fig. 62). These grains, however, do differ greatly in the quality of soil and care they need in order to produce profitable yields, and it is by taking advantage of these characteristics that the farmer may bring about significant cost variations.

### REGIONAL VARIATION IN COST OF PRODUCTION.

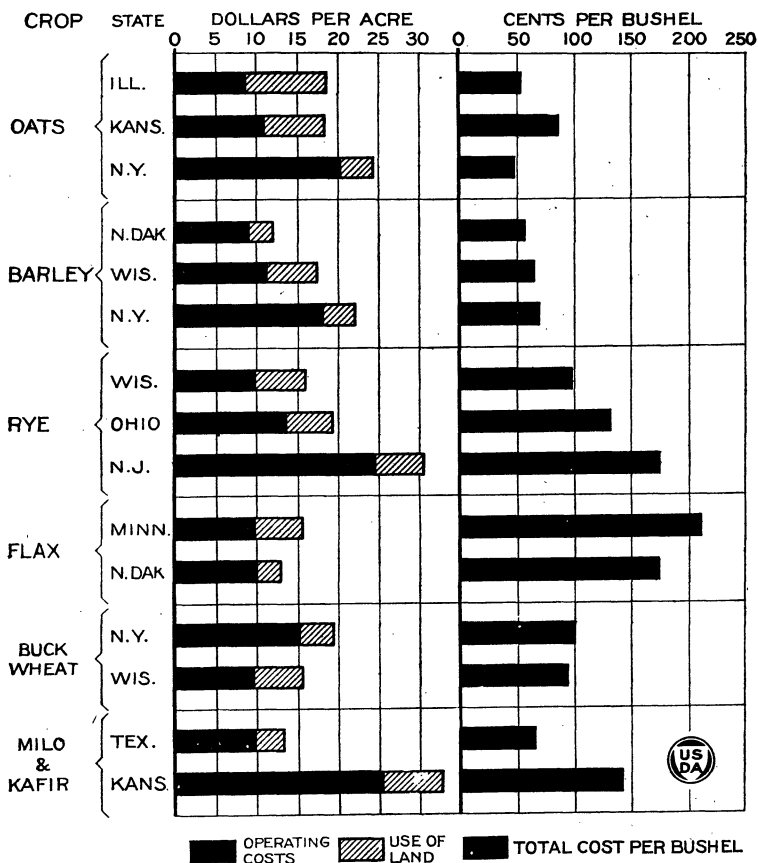


FIG. 62.—When comparing the cost of different crops, it is very important to state the basis on which the comparison is made. The above chart, for instance, shows that the cost of oats is the highest for New York on the acre basis but that Kansas is the high State when compared on the bushel basis. Furthermore, the acre cost of flax is lower than that of the other crops here shown while the bushel cost is highest.

The oat crop is able to adapt itself to a wide range of conditions. In some sections oats generally are grown on plowed land, but in others, like the Corn Belt, it is the common practice to disk them in on corn stubble, thus saving time and reducing the operating cost. Records show, for instance, that in Illinois only about 11 per cent of the crop was grown on plowed land, while in North Dakota the figure is 92 per cent.

Barley requires a better prepared seed bed than the other grains in order to produce a profitable yield. In most sections this means that the ground has to be plowed, with perhaps considerable disking and harrowing in addition, all of which increases the cost of production. Average figures for cost of producing barley should be carefully interpreted, however, because of the fact that it so often is used as a nurse crop. Under such conditions barley fields may be charged with certain operations like rolling and packing which would not be performed were barley sown alone. Furthermore, records for about 75 farms in Wisconsin on which 43 per cent of the barley area was seeded to grass showed that one-fourth of a bushel less seed was sown per acre when used as a nurse crop, which would tend to lower the cost of production.

Rye, like other grains, does best on rich soil, but because of its ability to produce more profitable yields than the other grains on the poorer soil it usually is relegated to sandy, low-priced land. It is a fall-sown grain and often is sown on corn and potato land, with very little seed-bed preparation other than disking or harrowing. Other things being equal, these facts would tend to reduce production costs and give rye a place in the cropping system on many farms.

Comparing all of the three crops from the standpoint of field preparation, we find that in Minnesota, where all these crops are extensively grown, 87 per cent of the barley, 75 per cent of the oat, and 50 per cent of the rye crop was produced on land that had been plowed. The same records show also that while 4.7 hours of labor were required by barley previous to harvest, rye received only 2.8 hours, which may mean a considerable saving when time is limited and wages are high. Although there are other factors that may

enter in to increase the cost of one of these crops over the others, it generally will be found that the total cost per acre for these three grains is lowest for rye and highest for barley in any given region.

### Rice.

In 1920 an investigation was made of the cost of producing rice in the three States of Texas, Louisiana, and Arkansas. The average results from 92 of the farms visited are given in Table 5. For the purpose of this analysis the costs have been separated into labor, power, materials, threshing, water, miscellaneous, and the cost of land.

*Labor.*—Labor is the most expensive single factor in rice production, representing about 40 per cent of the operating costs and about 33 per cent of the total cost. The cost of labor naturally varies considerably from farm to farm, but the averages for the three districts agree very closely. The hours of labor per acre were about 41, 35, and 43 for Arkansas, Louisiana, and Texas, respectively.

*Power.*—The tractor is more universally used in rice production than for any other crop, and for all districts it made up about one-third of the total power charges. The other two-thirds of the power cost was horse and mule labor, which averages about 41 hours per acre for each of the three sections. The combined cost of horses and tractors was about one-fifth of the total cost of production.

TABLE 5.—*Cost per acre of different items entering into rice production and total cost per acre in Arkansas, Louisiana, and Texas for the 1920 crop.*

State.	Number of farms.	Power.			Materials.	Threshing.	Water.		Miscellaneous.	Use of land.	Total.
		Labor.	Horse.	Tractor.			Cost of water bought.	Farm pumped water.			
Arkansas.....	36	\$21.61	\$13.55	\$8.33	\$11.52	\$2.63	.....	\$18.18	\$12.44	\$12.01	\$100.27
Louisiana.....	29	19.82	12.15	7.13	12.66	1.36	\$0.36	15.09	10.41	9.85	88.83
Texas.....	27	19.09	10.20	7.07	11.58	2.86	4.97	7.79	8.50	5.97	78.03
Total or average..	92	20.34	12.16	7.60	11.88	2.31	1.55	14.24	10.68	9.62	90.38



*Materials.*—This group includes the cost of fertilizers, seed, twine, and sacks. Of these, seed is the most important, amounting to about \$8 per acre or 9 per cent of the total cost. None of the other items is of outstanding importance, excepting perhaps sacks, which averaged about \$2.20 an acre in all sections.

*Water costs.*—Rice requires a large supply of water during certain periods and, consequently, water becomes a very important item in the cost of producing this crop. In Arkansas, where all of the farmers here included pumped all of the water, the average cost is \$18.18, while in Texas, where many bought either a part or all of the water used in irrigation, the average charge per acre amounts to \$12.76.

*Miscellaneous.*—In farm production there usually are a great many minor expenses that must be charged to the various productive enterprises. Some of these are true overhead charges, while others are direct charges but too small to be shown separately in general tables. Under "Miscellaneous" in Table 5 are included items like machinery, taxes, insurance, telephone, charge for buildings, etc. The largest item in this group is the cost of machinery, amounting to about \$4 per acre, while the second most important item is the cost of buildings, which is about \$3 per acre.

#### Grain Sorghums.

Unlike the small grains, grain sorghum is planted in widely spaced rows and cultivated. From the standpoint of labor, therefore, it is one of the intensive crops, comparing favorably with corn. The costs per acre and per ton for two districts, one in Texas and one in Kansas, are shown in Figure 62. In the two districts studied the practices are very different, with the result that there are large variations in costs. The two principal factors causing these differences are manure and labor. In Texas no manure was used, while in Kansas it was applied at the rate of about 5 tons per acre and was valued at \$1.50 per ton, which accounts for \$7.50 of the difference.

The labor records give 16.4 man-hours and 38.3 horse-hours for Texas and 25.2 man-hours and 42.2 horse-hours per acre for Kansas. This is due mostly to the fact that

in Texas the crop was harvested by cutting the heads from the standing stalks and generally was sold in the head. In Kansas, where the stalks are largely used for feed, the crop was cut with a corn binder and shocked. Later it was headed and thrashed, with only a small percentage fed as fodder. The result is that the harvest required only 6.7 man-hours in Texas compared with 12.9 in Kansas. The other costs, such as seed, twine, machinery, etc., also are small items in themselves but make up a total cost of about \$3.50 for Texas and \$6 for Kansas.

### Seed Flax.

Flax costs per acre are quite comparable to those of other grain crops (Fig. 62). A very large percentage of this crop, however, is grown on sod or on newly broken virgin land requiring a great deal of disking and harrowing for seed-bed preparation, which adds greatly to the cost. Comparable records for Minnesota show that flax received on an average 6.1 hours of man labor prior to harvest, while only 4.2 hours were spent on oats. Similar figures for North Dakota are 3.3 for flax and 2.9 for oats. Flax, as a rule, is cut with a binder without being tied into bundles. This saves the cost of twine, but the chief reason for the practice is that flax dries out too slowly when bound in sheaves and thus delays thrashing. Flax generally is thrashed out of the gavel.

In general, it may be said that flax is grown only in the highly specialized grain sections and hence is produced with the most modern grain machinery. This tends to reduce the cost of labor and power to the minimum. In North Dakota the cost of man and horse labor amounted to \$4.76 and in Minnesota to \$5.56 per acre. Charges other than for labor are about as follows: Seed, \$1 to \$1.50; machinery, \$0.50 to \$1; and overhead, \$0.50 to \$1; while thrashing, of course, varies directly with the yield, and land use with the value of the land on which it is grown and the interest and tax rates of the community. For North Dakota the cost of threshing flax in 1921 was \$3.78, while the average charge for land was \$3.88.

## Buckwheat.

Buckwheat often is spoken of as an "emergency" crop, because it so frequently is sown on land intended for other crops but which could not be sown, due to late spring, wet weather, or other causes. Because of this fact it very often is charged with the labor spent on the fields in preparing them for other crops. In general, however, this may be entirely legitimate, for buckwheat requires a well-prepared seed bed and consequently is benefited by whatever work is done prior to sowing.

In Pennsylvania and New York (Fig. 61), where most of the crop is grown, about 12 man-hours are 28 horse-hours are put on buckwheat before harvest, which is a very much higher charge than is common for other grains. The material charges consist of seed, usually sown at the rate of 1 bushel per acre, and twine, of which about 2 pounds are required by the average crop when cut with a binder. On many of the hilly farms in the East buckwheat is cut with a cradle, however, and bound by hand, and hence no twine is used. The other costs, consisting of machinery, thrashing, overhead, etc., generally run from \$2 to \$2.50 per acre.

## Estimating Costs.

Costs expressed in dollars and cents fluctuate from year to year with changes in the price of those items entering into production. Such figures, therefore, become quickly obsolete and of little value for many of the purposes for which the data were originally collected. This, together with the fact that farmers as well as students often are interested in forecasting costs for the year, makes it necessary to compute costs. Such computations may be worked out in several different ways, but Table 6 illustrates one method that is used commonly because it overcomes the difficulty of determining separately the cost of overhead, machinery, etc.

For this method three types of information are necessary: First, figures for the quantity of labor, power, and materials used; second, the price or cost rate at which these items should be charged; and, third, the relation of the combined total of labor and material to the total operating cost. Whenever the farmer is computing his own crop costs he

should use the hours of labor and quantities of material for his own farm whenever available; while in working up average costs, it is necessary, of course, to apply the proper rates to average standard requirements as determined by cost-accounting research.

TABLE 6.—*Example for computing the cost of producing grains, based on the estimated cost of producing oats in Wisconsin in 1922.*

Item of cost.	Average costs for 1922.				Your farm 1922.			Your farm 1923.		
	Unit.	Amount used.	Rates used.	Cost per acre.	Amount.	Price.	Cost.	Amount.	Price.	Cost.
<b>Man labor:</b>			<i>Cents</i>							
Before harvest .....	Hr.	6	25.0	\$1.50	.....	.....	.....	.....	.....	.....
In harvest and after...	Hr.	9	25.0	2.25	.....	.....	.....	.....	.....	.....
Horse labor .....	Hr.	24	15.0	3.60	.....	.....	.....	.....	.....	.....
Seed .....	Bu.	2.2	60.0	1.32	.....	.....	.....	.....	.....	.....
Twine .....	Lb.	2.5	14.0	.35	.....	.....	.....	.....	.....	.....
Coal for thrashing .....	Lb.	48	0.5	.24	.....	.....	.....	.....	.....	.....
Total labor and material cost (70 per cent of total) .....				9.26	.....	.....	.....	.....	.....	.....
Total operating cost (100 per cent) .....				13.23	.....	.....	.....	.....	.....	.....
Interest on land (5 per cent on \$90 per acre) .....				4.50	.....	.....	.....	.....	.....	.....
Total cost .....				17.73	.....	.....	.....	.....	.....	.....
Value of straw (0.8 ton, at \$5) .....				4.00	.....	.....	.....	.....	.....	.....
Net cost per acre .....				13.73	.....	.....	.....	.....	.....	.....
Cost per bushel (yield 40 bushels) .....				.34	.....	.....	.....	.....	.....	.....

<sup>1</sup> Different rates may be used for harvest labor, if so desired.

### Crop Position and Cropping System.

The position of 11 crops in American agriculture is shown in Figure 63. These crops are the four great staples, corn, wheat, hay, and cotton; and the seven crops under discussion in this article, namely, oats, barley, rye, rice, grain sorghums, seed flax, and buckwheat. The place of these crops in the rotation or cropping systems of the country is discussed briefly at the end of the article. The percentage

of cropped land in any given State or county which is devoted to any one crop at any one time depends on all the factors affecting all the crops grown there. The acreage of grain crops depends upon that of other crops. All the principal crops of the country are included in the chart (Fig. 63). This chart shows the percentage of the reported crop acreage occupied by each of these crops at each of the last five census periods, namely, 1879, 1889, 1899, 1909, and 1919. These five censuses cover a 40-year period.

To save space the States are grouped in this chart in so far as possible in such a manner as to bring together those having marked similarity in their agriculture. The most striking feature of the chart is the steadiness with which most of the crops have held their place in the farming of the various agricultural areas.

#### Position of Eleven Crops in American Agriculture.

*Corn.*—The only material change in the position of the corn crop is seen in the States of the Great Plains area. The decrease in percentage corn acreage in these States, except for 1919, is not due to decrease in actual acreage of corn but rather to a disproportionate increase in wheat acreage. This has resulted from the settlement of the drier western portions of these States, where wheat is well adapted but corn is replaced by grain sorghums. In 1919 there was an absolute decrease in corn acreage in this region, corresponding to the enormous increase in wheat area. But this latter phenomenon was temporary, and in 1920 both crops returned to approximately a normal acreage. In other parts of the country corn has held its relative position almost unchanged for nearly half a century.

*Wheat.*—The chart shows that wheat is the most variable in percentage acreage of any of the major crops. The price of wheat is dependent on world conditions. The crop is largely grown with limited rainfall, which causes great variation in production. The possibilities of production also are greater than the present world need. Overproduction and underproduction of wheat, therefore, are not infrequent, with resulting marked price variations, which in turn leads to variability of wheat acreage.\*

# PERCENTAGE OF TOTAL CROP AREA OCCUPIED BY EACH CROP.

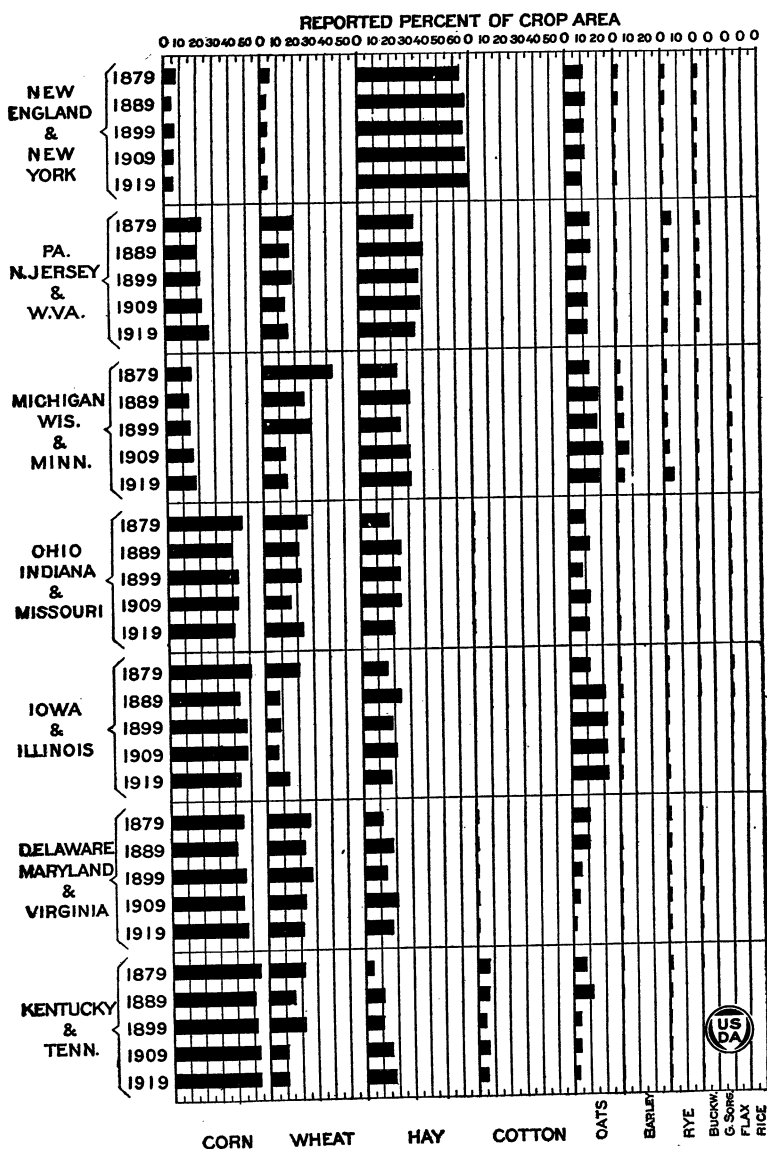


FIG. 63A.—Percentage of total crop area occupied by each of 11 crops, corn, wheat, hay, cotton, oats, barley, rye, buckwheat, grain sorghums, flax, and rice, in the years 1879, 1889, 1899, 1909, and 1919, in each of several groups of States having similar agricultural practices, and together comprising the entire United States. An increasing or decreasing percentage of acreage of any crop means a change in its relative importance but does not necessarily mean increasing or decreasing actual acreage.

# PERCENTAGE OF TOTAL CROP AREA OCCUPIED BY EACH CROP.

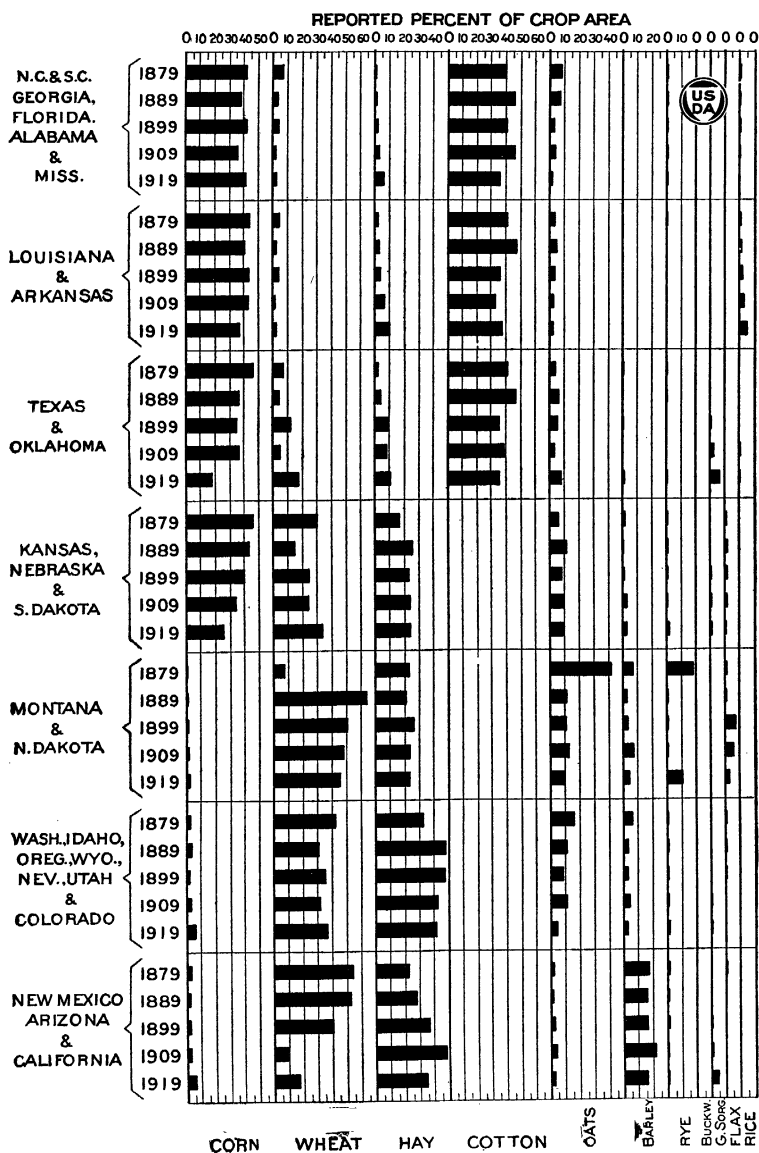
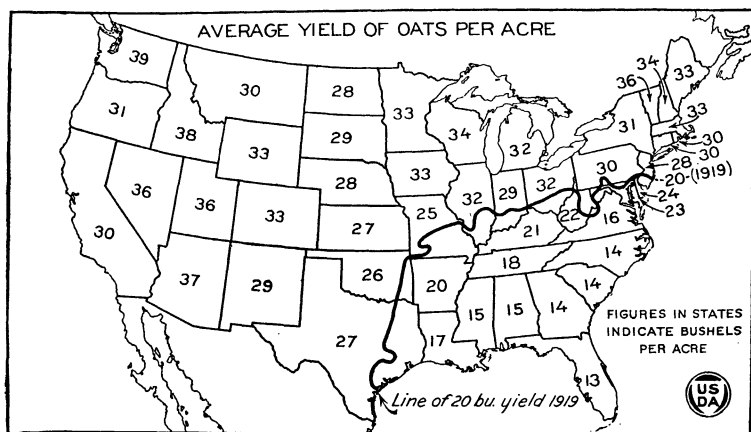


FIG. 63B.—Of particular interest in the above graph is the stability of the system of farming in New England and New York, in the Corn Belt, and in many other parts of the country, as indicated by the relative acreage of the several crops. In other areas changes have taken place; for instance, the decline in the relative importance of wheat in the Lake States and in California, and the small but steady increase in hay acreage throughout the South.

*Hay.*—The hay crop (Fig. 63) shows consistent increase in relative acreage in two general regions. One is the South, where the acreage of this crop is small, and where production is not sufficient to meet local requirements. The other is in the far Southwest, where hay, wheat, and barley are leading crops. The increase in the latter region has been at the expense of wheat acreage. Elsewhere the percentage area of hay has changed little in 40 years.

*Cotton.*—The percentage area of cotton is increasing in the far Southwest. It is decreasing along the southern edge of the central and eastern portions of the Cotton Belt, but this decrease is masked in Figure 63 by a corresponding increase in the northern portion of this region.

*Oats.*—The oat crop (see Figs. 3–11) is by far the most important of the small-grain crops after wheat. Figure 63 shows a consistent decrease in percentage acreage of this crop in the cotton States east of Texas and in the belt of States lying just to the north of them, as also in the western Mountain States. They are increasing in relative importance in the southern part of the Great Plains area and westward to California. Figure 64 tells the story of the





average acre-yield of oats by States for 50 years in most of the country but for only 20 to 40 years in the newer Western States. The line of 10 per cent oat acreage follows very closely the line of 20-bushel yield per acre in 1919. The small acreage of oats south of this 20-bushel line doubtless is to be attributed to the low acre-yield of this cereal in that region. North of this line oats occupy an important place in the agriculture of the region east of the Great Plains. In most of the mountain country oats are relatively unimportant. They are grown there mainly for use on the home farm, transportation to distant markets being too expensive for a cheap and bulky crop like oats. This is in spite of the fact that most of these Mountain States produce better yields and far better quality of oats than any other section of the United States.

*Barley.*—Figure 63 shows that barley (see Figs. 17–25) really is a major crop in the far Southwestern States. In California it is grown on a large scale for market. It is grown extensively in the Mountain States for feed. The product is too cheap to stand the high cost of transportation to distant markets. It also is important in the northern Great Plains area, mainly as a feed crop and to supply local markets. The only other section of the country where barley occupies any considerable portion of the crop land is in the northern dairy States of Michigan, Wisconsin, and Minnesota. It formerly was of some importance in New York and New England, but now has almost disappeared from the New England States, while the acreage in New York is much less than formerly.

Barley is an important substitute for corn in the feeding system along the northern edge of the Corn Belt and to the westward. It would doubtless be a more important crop if suitable varieties were available without the objectionable barbed awns which characterize most of the better varieties. Such varieties are being developed.

Our habit of measuring grain in bushels also has been disadvantageous to barley. A bushel of barley weighs 50 per cent more than a bushel of oats. If the yields of these two crops were commonly stated in pounds it would be more generally recognized that barley produces materially more

per acre than oats in most of the territory to which it is adapted.

In only a few localities does barley occupy as much as 10 per cent of the crop land. One of these is in the district surrounding the Twin Cities of Minnesota and western Wisconsin. In central California barley occupies 25 to 40 per cent of the crop area in several counties. In general, the barley region is seen to lie to the northward and westward of the important corn-growing region, although it overlaps the corn area considerably along its northern border.

*Rye.*—This crop formerly was of considerable importance in the northern half of the Atlantic coast region, but its percentage area is decreasing there (Fig. 63), and the crop has almost disappeared from New England and New York. In the north-central dairy States of Michigan, Wisconsin, and Minnesota rye has increased in importance consistently during the last two decades. The most remarkable change in the status of the rye crop in recent years is seen in the enormous increase in acreage in the spring-wheat area, principally in North Dakota. It is the only cereal sufficiently hardy to withstand the severe winters of that region. This fact is of importance in connection with seasonal distribution of labor. By putting part of his land in rye the farmer is able to get along with less hired labor. (See Figs 28–35.)

Rye has three characteristics which largely determine its distribution. It is the hardiest of the cereals, and hence extends farther north and west than winter wheat. It is adapted to sandy land. Finally, it is indifferent to wide variations in rainfall. This makes it a desirable crop for cold regions of deficient rainfall or with much sandy land. Its low price prevents it from being grown extensively for market where long-distance land transportation is necessary.

In general, the rye territory lies to the northward and westward of the winter-wheat area, but there is considerable overlapping of the two. Where they do overlap, wheat ordinarily is by far the more important. Rye occupies as much as 10 per cent of the crop acreage in only a few localities, the most important of these being central North Dakota and west-central Michigan.

*Rice.*—This formerly was an important crop on certain types of land along the south Atlantic coast, where the in-

dustry is a very old one (see Figs. 37–41). The War between the States almost destroyed rice culture in that section, but it revived again after the war to a considerable extent. However, with the development of rice culture on the level prairies of Louisiana, Texas, and Arkansas, which began in a large way in the early eighties, rice culture dwindled away in the Atlantic coast region and now occupies only a small acreage there. In the last 30 years, as Figure 73 shows, there has been a very large increase in rice acreage in Louisiana and Arkansas. More recently rice culture has appeared in California, where it has assumed considerable magnitude.

It still occupies a narrow strip along the South Atlantic coast and an extensive area along the Gulf coast in Louisiana and Texas, a strip along the Mississippi River in Louisiana, and a large district in eastern Arkansas. The California development is mainly in the Sacramento Valley.

Net exports and net imports show that we imported considerably more rice than we exported before the European war. During the war the price rose to enormous heights, and there resulted a very marked increase in production. Since 1914 we have exported much more rice than we have imported. Prices again are low, and it would be reasonable to expect a decrease in rice acreage in the near future. (See Fig. 44.)

*The grain sorghums.*—Kafir, milo, and related crops in the last quarter century have assumed an important place in the farming of the southern part of the Great Plains area and in the Southwest (see Fig. 46). They can be grown with relatively light rainfall as compared with corn, and this accounts for their prominence in the regions mentioned. In an important area in northwestern Texas crops of this group occupy more than 30 per cent of the crop area.

*Buckwheat.*—This crop is important only in the northern half of the Atlantic coast region (see Figs 58–61). It has held its place here very steadily for many years. It ripens in the shortest season of any of the grain crops and grows readily on poor land. It thus is especially adapted to higher altitudes in sections where the soil is none too good. Its greatest development is on the high lands of Pennsylvania and New York.

*Flax.*—This crop has had a varied history in this country (see Figs. 50–56). In the days of the old self-sufficing agriculture, preceding the advent of railroads, it was an important crop in Atlantic coast districts. As farming went westward flax followed and gradually disappeared from the East. It has now traversed the entire region from the Atlantic coast to the hard red spring wheat area (Fig. 63), which is the only section in which the crop is now important, and in that section it has decreased in acreage. According to the census of 1919, the crop was practically confined to Minnesota, central and northeastern South Dakota, North Dakota, and northeastern Montana.

Up to about 1908 we grew a surplus of flaxseed, in most years exporting considerable quantities. The price was low, and the acreage of flax decreased greatly between 1902 and 1909. The small crops of 1909 and 1910 resulted in the importation of flaxseed and a marked rise in price. In 1910 the users of linseed oil started propaganda for increased flax acreage in the Northwest. This resulted in considerable increase in area in 1911 and again in 1912. It happened also that there was a marked increase in acre yield in both these years, with the result that the crop of 1912 was more than twice as large as that of 1910. This caused prices to tumble, and they were at very low levels from 1912 to 1914, inclusive. Immediately there was a great decline in flax acreage. The acreage of 1921 was smaller than any reported acreage for 20 years. Since 1909 we have been importing large quantities of Argentine flaxseed. If flax acreage could be stabilized at a point that would still permit importations sufficient to govern prices, flax could be made an important means of diversifying agriculture in the spring-wheat States.